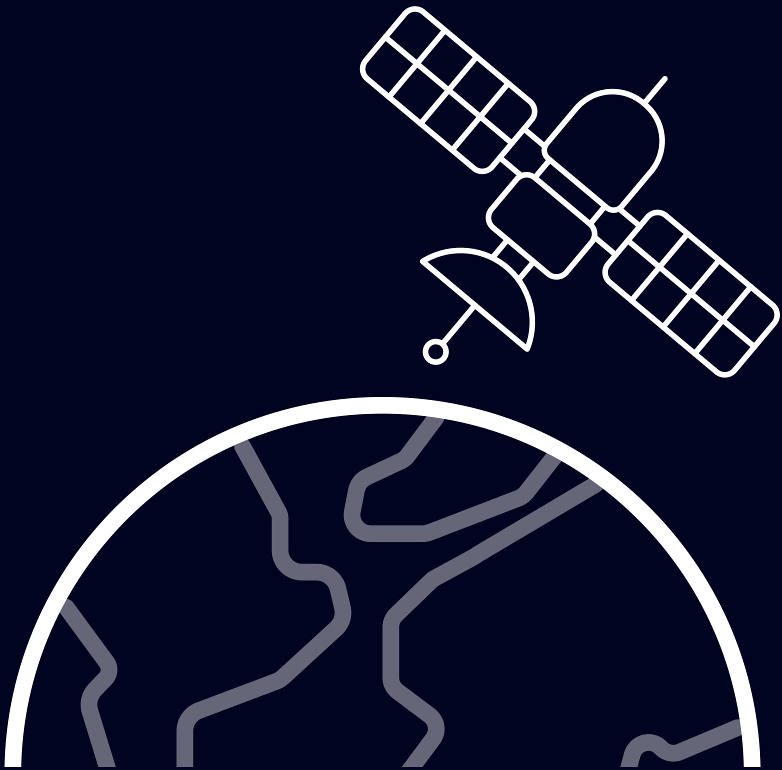

THE ETHICS OF OUTER SPACE EXPLORATION AND UTILISATION

REPORT • Adopted in September 2025

COMEST World Commission on the Ethics of Scientific Knowledge and Technology

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SHORT SUMMARY

How can we safeguard space as a shared heritage?

Across continents, the night sky has always had a quiet but profound influence on humanity. It has long helped people navigate, create myths, and reflect on their place in the universe. This relationship with space has also catalysed major technological advances. Space is no longer only observed; it can now be visited and may one day support permanent settlements.

Over 1.2 million of space debris large enough to cause catastrophic damage are currently in orbit

The entry of non-state actors has marked a new defining phase for the space sector. The number of satellites has skyrocketed and so has space debris. Lunar settlement, asteroid mining and space tourism are no longer distant ideas but are seriously discussed and planned. These spectacular developments are raising new ethical questions. Do we have a responsibility to protect extraterrestrial environments? How can we ensure that benefits are shared? Can space be considered a global commons?

With this Report, the World Commission on the Ethics of Scientific Knowledge and Technology call for reflection on ethical frameworks and global governance approaches to address modern complexities. Grounded in ethical principles, it offers concrete recommendations for Member States and all relevant stakeholders with the aim to ensure that humanity ventures into the cosmos responsibly.

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"Since wars begin in the minds of men and women, it is in the minds of men and women that the defences of peace must be constructed"

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FOREWORD

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Outer space has always captured humanity's imagination across cultures and continents. In the mid-1900s, this timeless fascination has developed into ambitious space programmes that have made remarkable advancements in space exploration and utilisation, inspiring countless generations. The world we live in today benefits enormously from these endeavours: instant communication, GPS navigation, wireless technology, solar panels, advanced medical tools such as diagnostic imaging and many other technologies were developed or significantly improved through space research.

Over the past two decades, the space industry has undergone a significant transformation, marked by a multiplication of actors, including non-state actors, engaged in space-related activities. Space has never felt so within reach, with the increasing presence of satellites changing the night sky and plans for lunar bases, Martian habitats and asteroid mining. These developments have been described under the concept of "New Space", which captures the emergence of a new space economy and evolving interplay between private and public innovation and investment.

In 2000, the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) published a report on the ethics of space policy. Twenty-five years later, its members felt compelled to revisit their ethical reflection to keep pace with the whirlwind developments in the field. The report also falls within the mandate of UNESCO's Social and Human Sciences Sector in environmental ethics. Following the Commission's reports on the ethics of water (2018) and land-use (2021), COMEST decided to extend its critical reflection to space, where human activity is increasingly impacting extraterrestrial environments.

Despite the many benefits enabled by space exploration and utilisation, several worrying trends have emerged, with impacts felt both in space and on Earth. The rapid expansion of space activity and infrastructure has indeed led to increasing congestion in orbit and growing pressure on the near-Earth environment. In 2023 the United Nations Office for Outer Space Affairs (UNOOSA) reported that nearly 17,000 satellites, probes, landers and station-elements have been launched since the space age. In the same year, a study published in the Science Journal found that the night sky has brightened by around 10% a year since 2011, largely due to light pollution and satellite mega-constellations. There is also growing concern that the benefits of space activity, such as the extraction of rare minerals, accrue disproportionately to spacefaring countries, while the risks and negative impacts are borne by all.

This new COMEST report responds to a dual imperative: to safeguard space as a shared heritage and to ensure that its development is guided by ethical principles, such as peace, equity and environmental protection. It stands as an important contribution to the debate on the global governance of space and the need for a more coordinated approach that reflects the growing number of actors. The report also offers a distinctive transhemispheric understanding of space, highlighting how diverse cultural interpretations of the cosmos can inform a more collaborative and sustainable use of space technology.

Although distant, what happens in space already profoundly affects life on Earth, and we must be careful not to extend the inequalities and divisions that exist on our planet beyond it. Instead, we must approach space with humility, recognising it as a global commons and a shared responsibility. It is my sincere hope that this report will guide the action needed to secure the benefit of all humankind, our planet and the cosmos, making ethics a cornerstone of decision-making.

Lidia Brito
Assistant Director-General a.i.
for Social and Human Sciences,
UNESCO

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This publication also greatly benefited from external consultation with specialised experts in the field. The Commission extends its heartfelt appreciation to those who generously reviewed the final draft and strengthened the publication through their thorough feedback: **Jacques Arnould**, Ethics Expert at the National Centre for Space Studies (CNES) in France; **Mario Castro Grande**, Senior External Affairs Officer at the International Telecommunication Union (ITU) ; **Jorge Del Rio Vera**, Scientific Affairs Officer at the United Nations Office for Outer Space Affairs (UNOOSA); **Sara Langston**, Space Law Expert at the United Nations Office for Outer Space Affairs (UNOOSA); **Anthony Milligan**, Research Fellow in Philosophy of Ethics at King's College London; and **Matthew Weinzierl**, Professor of Business Administration at Harvard Business School.

Within the framework of its work programme for 2024-2025, the World Commission of UNESCO on the Ethics of Scientific Knowledge and Technology (COMEST) decided to address the topic of the ethics of space exploration and utilisation. This initiative revisits and builds upon the Commission's previous reflections presented in its Report on the Ethics of Space Policy (2000). It also follows the more recent analyses of COMEST in its reports on Water Ethics: Ocean, Freshwater, Coastal Areas (2018), on Land-Use Ethics (2021) and on the Ethics of Climate Engineering (2023).

At the 13th (Ordinary) Session of COMEST in September 2023, the Commission established a Working Group to develop an initial reflection on this issue. The Working Group met online on several occasions in April and May 2024 to define the structure and the content of its report. The discussion of the Working Group was enriched by a private online Hearing Session on 21 May 2024 with prominent experts in the field. In preparation for the 13th (Extraordinary) Session of COMEST from 16 to 20 September 2024 at UNESCO Headquarters in Paris, the Working Group prepared a Concept Note providing a synopsis of its reflection thus far, which was presented and discussed at the public and private meetings of the session.

Consequently, the Working Group continued its reflection on the topic through exchanges of emails and regular online meetings. In preparation for the 14th (Ordinary) Session of COMEST from 15 to 19 September 2025, two online Working Group meetings were organized in May and in July 2025 to further develop the content of the report. In August 2025, an external consultation with specialised experts was organised to gather written feedback and comments on the progress achieved to date in the text. The final draft of the report was prepared during the above-mentioned online meetings and presented in the public meeting of the 14th (Ordinary) Session of COMEST. It was then revised and adopted by the Commission during the private meeting of this same Session on 18 September 2025.

This document does not pretend to be exhaustive and does not necessarily represent the views of the Member States of UNESCO.

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EXECUTIVE SUMMARY

Humanity stands at an inflection point in its relationship with space, transitioning from brief visits to an era of permanent settlement, intensive commercialization, and unprecedented access. This new chapter demands a robust ethical framework to ensure our celestial endeavours are sustainable, equitable, secure, and peaceful. This report synthesises a transhemispheric perspective on the pressing challenges ahead and charts a principled path forward.

The coming decade is defined by critical ethical concerns. The sustainability of Earth's orbit is threatened by proliferating debris that endangers vital infrastructure and by satellite mega-constellations that are rapidly brightening the night sky. Equitable governance requires transparent frameworks to manage space resource extraction and prevent exploitation, ensuring benefits are shared globally. Planetary protection protocols are needed to be widely implemented to prevent biological contamination both of Earth and celestial bodies, while also addressing planetary defence. Furthermore, the weaponisation of space and dual-use technologies pose profound security risks, necessitating stronger international agreements. Finally, space must remain a peaceful and inclusive domain, offering fair opportunities for participation, education, and research to all nations.

Addressing these challenges requires a foundation built on more than a solely Western paradigm. Responsible stewardship calls for a multicultural, "two-eyed seeing" approach that thoughtfully integrates Indigenous cosmologies with modern scientific understanding. This fosters necessary humility, balances ambition with cultural respect, and ensures local contexts are considered. From this vantage point, the report establishes nine core ethical principles to guide conduct: global equity and solidarity; peaceful cooperation through transparency; intergenerational justice via precaution and accountability; protection of data and assets; multispecies respect; security grounded in human dignity; cosmic environmentalism; the precautionary principle for uncertain impacts; and, fundamentally, treating space as a global-commons – a shared heritage of humankind.

Our current governance architecture, including the foundational 1967 Outer Space Treaty and UNCOPUOS, is critically outdated. A robust, enforceable system is urgently needed to close gaps in regulating resource ownership, countering modern militarisation threats like anti-satellite weapons, and establishing binding rules for environmental protection. In a landscape reshaped by private "New Space" actors, solutions may include new treaties, enhanced mandates for existing bodies, or consensus-based standards and new cooperative infrastructure. Transparency is

paramount and could be supported by a proposed Global Space Fund to finance research and equitable technology transfer.

The report begins by identifying a historic turning point, as space exploration shifts from brief visits to permanent settlement, driven by multinational and private-sector projects. It establishes two core imperatives: to safeguard space as a shared heritage and to align its development with equity, sustainability, and peace. To build a just foundation, Chapter II advocates for a transhemispheric understanding of space, moving beyond dominant Western paradigms to integrate Indigenous cosmologies through a "two-eyed seeing" approach. This multicultural perspective balances technological ambition with humility and cultural respect. Chapter III then surveys the current landscape of rapid advancement – from lunar bases and Mars exploration to space tourism – acknowledging both its profound benefits and concomitant risks, such as space debris, geopolitical tension, and planetary contamination.

Chapters IV and V form the ethical and governance core of the report. Chapter IV details nine tailored ethical principles for space, addressing concerns from global equity and peaceful cooperation to multispecies respect, cosmic environmentalism, and the foundational debate over whether space is a global commons. These principles directly inform the call for governance reform in Chapter V. It argues that while foundational treaties like the 1967 Outer Space Treaty provide a starting point, they are now inadequate. A robust, implementable global framework is urgently needed to address critical gaps in regulating resource ownership, countering modern militarisation and establishing binding environmental protections. This new governance must be inclusive, transparent, and adaptable to an era dominated by "New Space" commercial actors, potentially supported by mechanisms like a Global Space Fund to ensure all nations can participate in and benefit from humanity's cosmic future.

To operationalise this vision, the report proposes a concrete seven-step roadmap: strengthening international cooperation and governance; applying the precautionary approach; ensuring equitable resource distribution; integrating ethics with emerging AI and robotics; promoting exclusively peaceful use; enhancing transparency and accountability; and developing public engagement tools like a "Space Ethics Scale." These actions are prioritized across short-, medium-, and long-term phases.

As a species poised for deeper exploration, we face a transformative moment. Space ethics provides the essential compass to navigate this frontier, ensuring our journey into the cosmos uplifts all of humanity and preserves the celestial realm for generations to come.

LIST OF ACRONYMS

Action Team on Lunar Activities Consultations (ATLAC)

Anti-Satellite (ASAT)

Astronomical Unit (AU)

Committee on Earth Observation Satellites (CEOS)

Committee on Space Research (COSPAR)

Global Positioning System (GPS)

In-Situ Resource Utilization (ISRU)

International Asteroid Warning Network (IAWN)

International Astronomical Union (IAU)

International Research and Lunar Science (IRLS)

International Space Station (ISS)

International Telecommunication Union (ITU)

James Webb Space Telescope (JWST)

Lunar South Pole-Aitken (SPA)

National Aeronautics and Space Administration (NASA)

National Space Council (NSC)

Near-Earth Objects (NEO)

Outer Space Treaty (OST)

Potentially Hazardous Asteroids (PHA)

Space Mission Planning Advisory Group (SMPAG)

Space Resources Working Group (SRWG)

United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)

United Nations Office for Outer Space Affairs (UNOOSA)

United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER)

World Commission on the Ethics of Scientific Knowledge and Technology of UNESCO (COMEST)

Working Group for Planetary System Nomenclature (WGPSN)

Working Group on Star Names (WGSN)

I.
INTRODUCTION

1. Humanity's relationship with outer space (henceforth referred to as 'space' in the report) is etched into the fabric of our existence. For millennia, the night sky has served as both compass and canvas: ancient cultures mapped constellations to navigate land and seas, wove myths from celestial patterns, and aligned megaliths to track solstices. Cave paintings dating back over 30,000 years reveal early attempts to decode cosmic rhythms, while Assyro-Babylonian astronomers systematised observations of planetary motions by 1000 BCE. These endeavours reflect a universal drive: to understand our place in the cosmos. Even the stars themselves bear witness to this timeless quest, their positions shifting over epochs due to galactic rotation and Earth's axial wobble, reminding us that exploration is woven into the very motion of the universe.

2. From the earliest cave paintings mapping celestial patterns to the modern era of lunar habitats, humanity's relationship with space has been defined by curiosity, ingenuity, and aspiration. For millennia, the stars have guided navigation, inspired mythologies, and kindled our collective imagination–a testament to space's enduring role in shaping human identity. This legacy continues to evolve as technological leaps transform space from a realm of wonder into a frontier of tangible possibility.

3. This innate curiosity has catalysed technological leaps. Ground-based observatories, such as those in high-altitude deserts and remote islands, now scan the skies for exoplanets and asteroids, while mobile telescope networks track space debris and validate spacecraft deployments. Innovations such as adaptive optics and reusable rockets have democratised access to space, enabling missions to Saturn, Jupiter and the Trojan asteroids. Yet the journey from imagination to reality was neither linear nor solitary. Visionaries like Konstantin Tsiolkovsky laid the theoretical groundwork for escape velocity, while later engineers transformed these principles into vehicles capable of reaching the Moon. Such a leap was foreshadowed in tales like *The Tale of the Bamboo Cutter*[1], written in Japan between the 9th and 10th centuries, or in Jules Verne's cannon-propelled voyage in the 19th century. The 20th century's geopolitical competition accelerated progress, but so did collaborative breakthroughs, proving that exploration and utilisation thrive on both competition and cooperation.

4. Ground-based observatories, robotic missions, and reusable launch systems now enable unprecedented exploration and utilisation, while debates over resource rights and lunar colonisation signal a paradigm shift: space is no longer merely studied but actively used and subject to plans for further utilisation. This new era demands ethical vigilance. As commercial ventures and multinational collaborations accelerate, the line between exploration and exploitation blurs.

5. The World Commission on the Ethics of Scientific Knowledge and Technology of UNESCO (COMEST) report emerges in response to dual imperatives: to safeguard space as a shared heritage and to align its development with ethical principles such as equity, sustainability and peace. Grounded in the ethos of Margaret Mead's call to unite under "common stars," this document interrogates how emerging technologies, from asteroid mining to off-world

1 *The Tale of the Bamboo Cutter* tells the story of a girl born from bamboo, who is revealed to be a Moon person that ultimately travels back to the Moon at the end of the tale.

settlements, can serve international agreements such as the 2030 Agenda for Sustainable Development, rather than deepen terrestrial inequities. By weaving historical reflection with forward-looking governance frameworks, it challenges stakeholders to reimagine space not as a geopolitical arena, but as a collaborative endeavour where innovation serves humanity's highest ideals.

6. Today, we stand at an inflection point. Plans for lunar bases, Martian habitats, and asteroid mining signal a shift from transient visits to permanent settlement. This new era, driven by multinational partnerships and private-sector initiatives, demands comprehensive ethical frameworks and a global governance approach. Existing treaties, conceived in an age of state-dominated exploration, strain under the weight of modern complexities, such as commercial resource extraction, militarisation risks and the 'race for permanence' in space.

7. The structure of the report is as follows. It introduces 'Transhemispheric Understanding of 'Space' in Chapter II, tracing humanity's celestial fascination from ancient stargazers to modern scientists, emphasising how diverse cultures have interpreted the cosmos and highlighting exploration as a universal driver of progress and innovation. The next chapter 'Current Research and Development' briefly provides some examples of space activities and their technologies and examines advancements in ground- and space-based technologies (e.g. adaptive optics, reusable rockets) that broaden access to space while raising ethical questions about environmental and geopolitical impacts. This chapter also discusses opportunities, risks, benefits and harms arising from these space activities. Chapter IV on 'Navigating the Ethical Concerns about Space Exploration and Utilisation' identifies various principles that are important to mitigate identified ethical concerns in the context of these new space endeavours. The report continues with a chapter on 'Cooperation for a Global Governance Framework'. Finally, Chapter VI concludes with a set of recommendations and a suggested roadmap.

8. As we gaze toward the stars, this report challenges us to consider whether space should be viewed as a frontier to claim or as a 'global commons' to steward. By bridging ancient wonder with modern responsibility, we can ensure that the next chapter of exploration and utilisation uplifts all humanity, forging a legacy worthy of the cosmos that inspires it.

II.
TRANSHEMISPHERIC UNDERSTANDINGS OF ‘SPACE’

9. The skies are seen and experienced from Earth every day; they are the most connective experience with the cosmos that any living being can have. Our daily life is an intricate relationship with the above, the here, and the below, the sky, the wind, the land, and the (under)water. What marks the everyday is the Sun rising and setting, the changing phases of the Moon, the movements of the planets, and the star-filled skies and their patterns, occasionally obscured from us by clouds. Every society that exists on Earth experiences the Sun, Moon, and stars; each has tried to understand the skies and their phenomena. This experience is conditioned by geographic and cultural location.

10. For millennia, and for the everyday person, experience and knowledge of the skies have been and is an outcome of observing without touching. Untouched, the sky governs daily life. Its rhythms guide humans, animals and plants. Artificial lights challenge, but never equal, the Sun's quality. For most, this image of the sky's distant influence persists innocently.

11. Many societies kept records of their sky observations, some written and preserved in stone, clay or wood, others in memory and performative forms. They deployed skywatchers or naked-eye astronomers, to observe, calculate and keep records of the skies and starry activities: computing the length of the year, months, seasons, tides, agriculture, reproductive cycles and more.

12. The decisive break from this Earth-based observation of the skies to space-based observation of the Earth–the emphasis on 'space' rather than 'skies'–took place with robotic spacecraft in 1957 and human missions in 1961 into 'space'. Up until then, specialised observation of the skies that brought stars and planets closer used a telescope.

13. In the Americas, Asia, Pasifika, and Africa, European colonial rule splintered Indigenous sky knowledge. A complex interplay of factors, including military conflicts, the introduction of European diseases to which Indigenous peoples had no natural immunity, the loss of significant cultural texts and the diminishing numbers of Indigenous astronomers, contributed to a profound transformation of knowledge about the cosmos. This process began with the Spanish and Portuguese in the 1500s, followed by the British and French in the 1600s, and eventually involved many other Western European countries as they sought to occupy these regions and share their own beliefs about the skies.

14. It was not just the land, language or culture that colonialism occupied, but also time, the day, and the 'every' in 'everyday' itself. Indigenous time was either replaced by or folded into colonial time and came to be counted in seconds, minutes, hours, days, weeks, months and years, with the seasons assigned European names. The Gregorian calendar became the standard in the 'New World' after 1582, and later in Asia, Arabia, Persia, Aotearoa and Africa. The skywatcher and timekeeper gave way to clocks and watches. Indigenous astronomy became first 'native astronomy' and then 'ethno-' or 'cultural' astronomy, but not actual (scientific) astronomy as judged by Western-centric scholars.

15. Stars and constellations now assumed non-local names, replacing local names with meaning and spirit, which encrypted local sciences and technologies, with Greek nomenclature. However, the International Astronomical Union (IAU) is actively incorporating Aboriginal names for stars and planetary features through collaborative processes, often consulting with Indigenous communities to adopt culturally significant names like 'Larawag' (for ε Scorpii) or 'Ginan' (for ε Crucis). This practice reflects the IAU's commitment to diverse cultural heritage in astronomy nomenclature, governed by specific working groups like the Working Group on Star Names (WGSN) and the Working Group for Planetary System Nomenclature (WGPSN)[2].

16. It is noteworthy, however, that even while official sciences of the skies became Europeanised, skywatching continued to be practiced in everyday life among everyday people.

2 For detailed naming rules and approved names, visit the IAU's official nomenclature portal at the following address: https://iauarchive.eso.org/public/themes/naming/

II.1. Why a transhemispheric perspective needs to be an option

17. The transition from Indigenous astronomy–rooted in ancient, holistic relationships with the cosmos–to Western-centric systems has perpetuated a 'one-eyed seeing' paradigm, privileging Euro-American frameworks that have shaped space agencies. This influence often marginalises Indigenous knowledge, which for millennia has woven science, spirituality and sustainability into a tapestry of cosmic understanding.

18. A transhemispheric approach to the skies would seriously consider the rights of Indigenous activists who have pointed to 'two-eyed seeing' attitudes. This refers to "see[ing] from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of Western knowledges and ways of knowing, and to use both these eyes for the benefit of all", as stated by the Native Skywatchers (n.d.), citing Bartlett, Marshall and Marshall (2012). This approach enables us to balance technological ambitions with humility toward the cosmos.

19. Transhemispheric thinking entails a broad range of experiences, cosmologies, knowing-what and knowing-how, including approaches that do not privilege established space agencies. Today, the profit imperative of corporations has flooded the night skies with artificial lights. The bright night sky may represent a lack of respect towards the sky from the perspective of some Indigenous cultures. A generation obsessed with satellite-dependent information technology is making a growing footprint in the skies. It is essential therefore to imagine a space order founded upon Indigenous traditions of interacting with the sky "without touching", in search of foundations for designing a transhemispheric connection with the skies. Indigenous beliefs that planets are gods reflect an understanding of the powerful influence solar, lunar, constellational and galactic forces have over humanity. This perspective arises from a humble respect for the power of non-Earth planets over the universe and the survival of the cosmos.

20. In these Indigenous societies, the production of knowledge and technologies to understand the skies was aimed at mollifying and satisfying these cosmic forces to increase benefits (benevolence) and minimise harm (maleficence) to mortals. Of note are the technologies that societies developed to understand, anticipate, and map the benevolent and malevolent (re)actions of these deified solar, lunar, planetary and celestial entities.

21. As more countries participate in space endeavours, these initiatives need to honour both the stars above and the communities below, blending innovation with humility to address earthly needs like sustainability, equity and resilience. In this fusion of ancestral reverence and modern ambition, we see a vision of space exploration and utilisation that transcends divides: one where progress is measured not only by technological prowess but by its power to uplift humanity as a whole.

22. What principles guide our decisions about 'touching' celestial bodies, governing their use or harnessing their resources? How do we balance scientific curiosity and technological ambition with humility toward the cosmos? Rather than framing space as a frontier to 'conquer', we might prioritise collaborative, sustainable engagement, approaching exploration and utilisation with temperance, transparency and reverence for the interconnected systems we are part of. This means acknowledging the risks of irreversible harm and committing only to technologies and policies that honour both human ingenuity and the integrity of the universe we seek to understand.

23. Is it possible, therefore, to "imagineer" (imagine and engineer[3] (Alcoa, 1942)) an order of space based for instance on the ancient Egyptian ethic of *Maat* (a space of justice, solidarity, order, and balance) versus its opposite, *Isefet*? Or on the Quechua ethic of *Sumak kawsay*, which means living in harmony or living in plenitude, wherein we become what the Māori call *kaitiaki* (guardians) over the land, sea, and sky, or on ubuntu (humanity to others).

24. The greatest concern is the increasing technological likelihood and capability of actors arming and counter-arming space. While advancements in space technology hold immense promise, they also remind us of our shared responsibility to channel innovation toward peace, not conflict. By uniting countries in dialogue and cooperation, these actions can then transform the spectre of space militarisation into an opportunity to safeguard the cosmos as a sanctuary for collaboration, ensuring that humanity's next frontier reflects our highest ideals, not our divisions.

25. By embracing collaboration over competition, we can forge a new chapter where innovation in the cosmos is guided by shared stewardship, ethical foresight and a collective vision, proving that the stars, free from Earth's old divides, might inspire our highest potential to lead with wisdom, not just power.

3 Alcoa introduced "Imagineering" in a 1942 Time magazine advertisement to describe blending imagination with engineering to create new uses for aluminium, defining it as "letting your imagination soar, and then engineering it down to earth".

III.
CURRENT RESEARCH AND DEVELOPMENT

26. Space exploration and utilisation have entered a defining phase, marked by accelerating technological and commercial advancements. In the next decades, space travel will become more common and commercialised, providing new possibilities, such as space tourism, planetary human permanent presence and space utilisation, all of which bring about ethical challenges. This section highlights certain aspects of space activities as illustrative examples, without intending to offer an exhaustive list of space operations. Appendix I provides a sample list with more information on space efforts. However, the dynamic and ever-changing landscape of space endeavours entails that it may not capture the most recent advancements.

III.1. Moon

27. The Moon is a key target for exploration and utilisation due to its closeness and potential as a resource reservoir and as a platform for advancing technologies. Furthermore, its critical scientific value and its role as a staging point for missions to deeper regions of the solar system are crucial. The cislunar environment, spanning Earth-Moon space, as well as the lunar south polar region are strategically significant for establishing infrastructure to support sustained lunar operations and interplanetary missions. This region enables applications ranging from scientific research–such as studying the Moon's geologic history and its role in stabilising Earth's axial tilt–to In-Situ Resource Utilisation (ISRU), including water ice extraction for life support and propulsion. The Lunar South Pole-Aitken (SPA) basin, one of the oldest and largest impact structures in the solar system, harbours permanently shadowed regions containing primordial volatiles such as water ice, likely preserved from the early solar system. These deposits are scientifically valuable for understanding planetary formation and practically essential for sustaining long-term habitats. Ethical frameworks for lunar stewardship must prioritise minimising contamination, preserving pristine environments for study and ensuring equitable access to resources. Beyond its scientific value, the Moon's gravitational influence moderates Earth's axial precession, contributing to Earth's climatic stability over geological timescales, while its surface offers unique opportunities for radio astronomy (especially on the far side) and testing closed-loop life-support systems.

28. Lunar exploration and utilisation are increasingly driven by collaborative international frameworks and public-private partnerships. The Artemis Accords, a multilateral agreement signed by many states, outlines principles for peaceful exploration, transparency and interoperability of systems, including shared standards for lunar infrastructure. A key initiative under this framework is a planned lunar-orbiting platform designed to support crewed missions, deep-space research and logistics for surface operations. Its modular architecture includes propulsion, habitation and airlock systems, with deployment forthcoming. Concurrent robotic missions–such as orbiters, landers and sample-return spacecraft–are mapping volatiles, characterising regolith or soil and testing ISRU technologies. Recent efforts include a lunar sample-return mission targeting the SPA basin and proposals for a robotic research station in the same region. Meanwhile, commercial ventures are advancing SmallSat orbiters, landers and microrobotic payloads, with multiple private missions scheduled to demonstrate precision landing, resource prospecting and telecommunications. The International Research and Lunar Science (IRLS) collaboration in the SPA basin aims to leverage the expertise of multiple countries and institutions to conduct cutting-edge research and exploration initiatives, enhancing our understanding of lunar resources and supporting sustainable robotic and human presence on the Moon. These efforts align with long-term goals to establish a sustained human-robotic presence, including habitation modules and a cislunar communications network by the mid-21st century. Global participation spans robotic exploration consortia, academic institutions and industry stakeholders, reflecting a shift toward decentralised, cooperative models of space exploration and utilisation.

III.2. Mars

29. Mars presents a compelling target for human exploration, utilisation and habitation due to its relative similarities to Earth, including subsurface water reservoirs, a thin atmosphere offering partial radiation shielding and geological features such as lava tubes and caves that could provide natural shelter.

30. These attributes make it a focal point for astrobiological research, with ongoing efforts to detect biosignatures using robotic orbiters, landers and rovers. Decades of robotic exploration have revealed insights into its geological history, climate cycles and resource distribution. Early missions in the mid-20th century achieved milestones such as the first successful flyby and subsequent landing attempts, while later missions established long-term orbital operations, enabling continuous climate and surface monitoring. A sustained programme of exploration initiated in the 1990s prioritises collaborative science, resilient infrastructure development and phased advancements toward human self-sufficiency. This framework integrates lunar exploration as a proving ground for technologies such as ISRU and closed-loop life-support systems, which are critical for reducing Earth dependence during interplanetary missions.

31. Global initiatives emphasise the need for multilateral cooperation to address the technical and ethical challenges of Mars exploration and utilisation. A cornerstone of these efforts is a sample-return campaign utilising robotic systems to collect and transport Martian regolith and atmospheric samples to Earth for detailed analysis, informing both astrobiological research and human mission planning. Concurrently, studies on terraforming–modifying planetary environments to support terrestrial life–remain theoretical but concepts like atmospheric thickening and subsurface habitat engineering are being studied. Active surface rover missions are analysing mineralogy, hydrology and radiation exposure, while orbital assets map resources such as water ice. Near-term objectives within the next decade include deploying advanced rovers, testing ISRU prototypes and establishing communications networks. Longer term visions propose crewed missions supported by modular habitats, potentially leveraging natural shelters like lava tubes to mitigate radiation risks and using the Martian moons as space stations. Commercial ventures are also advancing heavy-lift launch systems and autonomous landing technologies, aiming to enable cargo pre-positioning and infrastructure deployment. These collaborative endeavours, spanning academic, governmental and private sectors, reflect a shared commitment to phased, sustainable exploration and utilisation, balancing scientific discovery with stewardship of extraterrestrial environments. However, agreements and a governance framework need to be developed and implemented.

III.3. Astrophysics

32. The deployment of a next-generation space observatory (e.g. the James Webb Space Telescope (JWST)) has revolutionised observational astronomy, enabling unprecedented study of cosmic phenomena across the full electromagnetic spectrum. This observatory, developed through multinational collaboration, was designed to investigate the formation of the first stars and galaxies, analyse the chemical composition of exoplanet atmospheres and trace the evolution of planetary systems. Its infrared capabilities allow it to peer through interstellar dust, revealing processes such as star birth in nebulae and the dynamics of early-universe black holes. Recent theoretical work proposes that primordial black holes, which are tiny black holes theoretically formed in the early universe, could leave observable signs of their passage through solid objects including minerals found on Earth. These signatures could manifest as microscopic tunnels in materials like rocks, metal or even glass. Such studies underscore the value of integrating multidisciplinary, multi-scale observational and experimental approaches.

33. Ground-based observatories complement space-based instruments by leveraging adaptive optics to correct atmospheric distortion, enabling high-resolution studies in wavelengths ranging from visible wavelengths to radio wavelengths. Arrays located in high-altitude desert regions and remote mountain sites provide critical data on stellar evolution, galactic structure and transient events like supernovae. Recent advances in ground-based imaging achieved a milestone with the first detailed resolution of an individual star in a neighbouring galaxy, highlighting synergies between terrestrial and orbital platforms. Together, these systems form an interconnected observational network, combining the atmosphere-penetrating power of space telescopes with the precision and upgradability of Earth-based facilities to advance our understanding of the Universe's evolution, exoplanet habitability and fundamental physical processes.

III.4. Near-Earth Objects (NEO)

34. NEOs are asteroids or comets with orbits intersecting Earth's vicinity that are critical targets for planetary defence and scientific inquiry. Defined as bodies passing within 1.3 astronomical units (AU) of the Sun or over 150 million kilometres, these remnants of the solar system's formation pose collision risks, particularly those larger than 140 metres which are classified as Potentially Hazardous Asteroids (PHA). A global collaborative network coordinates the detection, tracking, and characterisation of NEOs and PHAs through integrated ground- and space-based systems (e.g. IAWN International Asteroid Warning System, etc). Ground-based telescopic surveys such as wide-field sky scans and infrared observatories identify faint or thermally dim objects, while computational models assess orbital trajectories and impact probabilities.

35. The International Asteroid Warning Network (IAWN) is a worldwide planetary defence collaboration of organisations and individual astronomers recommended by a United Nations (UN) resolution who collectively work to detect, monitor and characterise potentially hazardous asteroids and NEOs. If an asteroid threat were ever identified, IAWN would act as a centralised hub for disseminating information to governments to aid with analysis of impact consequences and with planning of mitigation response options. Joining the IAWN which is a UN-endorsed global collaboration, it would strengthen planetary defence by enhancing collective capability to detect, monitor and characterise NEOs and ensure a coordinated, informed response to any potential impact threat. In the event that an impact threat is identified, then the Space Mission Planning Advisory Group (SMPAG) is activated.

36. For example, a recent 40–90-metre asteroid detected by sky-survey systems underwent rapid trajectory analysis by an international network of observatories, confirming a safe passage by Earth. This framework emphasises early threat detection, enabling deflection mission planning while advancing understanding of solar system dynamics and resource potential. Emerging technologies, including compound-eye telescopes and automated alert systems, enhance sky coverage and response times, underscoring the necessity of sustained innovation and multilateral data-sharing to mitigate risks and refine cosmic threat preparedness. Ground-based astronomical infrastructure plays a pivotal role in both planetary defence and deep-space exploration. High-altitude observatories equipped with adaptive optics and radio-telescopes provide precision tracking of NEOs, exoplanet atmospheres, and transient cosmic events, while mobile telescope networks map asteroid populations via stellar occultations.

37. These systems also validate spacecraft deployments and mission trajectories, such as studies of planetary ring systems and small-body flyby planning. Complementary to orbital observatories, terrestrial facilities operate across visible and radio wavelengths, unhindered by atmospheric absorption in certain bands. Communication networks including deep-space antenna arrays maintain real-time data transmission with interplanetary missions, enabling remote operation and scientific data retrieval. Collaborative frameworks integrate these capabilities, supporting objectives from impact risk mitigation to interstellar probe navigation. However, the danger posed by NEOs and PHAs in the equatorial zone of Earth, due to the lack of observations from that region, highlights the urgent need for more observatories to enhance tracking and monitoring efforts. This synergy between ground-based precision, space-based spectral coverage and computational modelling exemplifies the interdisciplinary collaboration required to safeguard planetary systems and advance humanity's capacity to explore and utilise space sustainably.

III.5. Space tourism

38. Commercial human spaceflight began in 2001 with the first privately funded individual traveling to a crewed orbital platform aboard a reusable spacecraft, marking the inception of suborbital and orbital tourism. Subsequent advancements in reusable launch systems enabled commercial entities to develop vehicles for brief suborbital flights, offering passengers minutes of microgravity and Earth observation. While crewed lunar missions remain aspirational, multiple commercial providers have proposed circumlunar expeditions within the next two decades, leveraging next-generation heavy-lift rockets and modular spacecraft. These initiatives aim to extend access beyond trained astronauts to private citizens, contingent on advancements in life-support systems, radiation shielding and cost-reduction strategies. Recent milestones include privately funded orbital missions to crewed platforms, demonstrating the feasibility of civilian crew participation. Current regulatory frameworks focus on safety standardisation and liability protocols to address the unique risks of commercial space travel, including high-acceleration environments and re-entry thermal stresses. The industry's evolution reflects growing technological parity between governmental and private-sector capabilities, with lunar tourism poised to expand humanity's presence beyond low-Earth orbit.

III.6. Opportunities, risks, benefits and harms

III.6.1. Opportunities and benefits

39. Space exploration and utilisation have propelled human innovation and technological advancements for humanity. The world we live in today, with all the benefits of instant communication, new materials (e.g. memory foam, lightweight materials), Global Positioning System (GPS), wireless technology, medical tools and techniques (e.g. diagnostics tools, heart monitors, cancer therapy), camera phones, solar panels and water purification systems, has been enhanced by space exploration. Many of the daily items we use today are derived from space developed technologies.

40. Over five decades of human activity in space have produced societal benefits that improve the quality of life on Earth and enable a better understanding of Earth's resources. From the first satellites launched to study the space environment, critical knowledge and capabilities have been gained for society. Satellites provide critical data for monitoring Earth's climate, deforestation, natural disasters and pollution, and for improving weather forecasting. This data is vital for environmental conservation and climate change mitigation efforts.

41. As we proceed with these space endeavours, new opportunities are emerging. One of these is the use of space material resources. Until recently, space missions have focused on scientific research and knowledge gathering. Today, this space economy includes profit-making goals, considerably changing the equation and demonstrating the need for a global legal framework that supports sustainable collaboration in this emerging economy. The private sector and governments are already preparing for the utilisation and development of space resources and within the next decades, there could well be a self-sustaining space industry which would include space tourism and space militarisation. The inspirational nature of space exploration and utilisation have encouraged generations of students to pursue careers in science, technology, mathematics and engineering. These students and professionals have provided and will continue to provide unique and innovative solutions to many societal challenges.

42. The landscape of opportunities in space is undergoing a remarkable transformation, driven by technological advancements and an increasing interest in space resources. Private enterprises, sometimes in partnership with government agencies, are spearheading initiatives that encompass everything from satellite launches to space tourism, creating a dynamic marketplace for innovation. Access to space by many entities—governmental, private and commercial—has reached unprecedented levels, among them efforts focused on asteroid mining for precious resources, the development of lunar bases for research and habitation and even ambitious near-term plans for human missions to Mars. As countries work together and compete for dominance in this new frontier, the prospects for economic growth, scientific breakthroughs and international collaboration signal an exciting future, but one that requires a global legal framework.

III.6.2. Risks and harms

43. Human space exploration and utilisation face significant physiological and environmental challenges. Prolonged exposure to cosmic radiation beyond Earth's limits, as experienced on Mars or the Moon due to non-existent or thin atmospheres and weak magnetic fields, together with microgravity-induced health risks (e.g. bone loss, vision impairment) and psychological stressors, necessitates advancements in protective technologies. While robotic missions (e.g. rovers, orbiters) mitigate initial risks by preparing the way for humans and enhance scientific returns, sustainable exploration and utilisation requires integrating human and robotic efforts. Concurrently, space activities generally generate orbital debris, threatening satellites and future missions, while rocket emissions (black carbon, reactive chlorine and nitrogen oxides) contribute to atmospheric pollution and ozone depletion.

44. Expanding human presence to the Moon, Mars and deep space introduces ethical and geopolitical challenges. Unexplored lunar and Martian caves, potential sites for microbial life or habitats, demand governance frameworks to balance exploration and utilisation with preservation. Discovering extraterrestrial life would point to a need to reflect on what the ethical obligations are in order to avoid contaminating fragile ecosystems, requiring stringent protocols against 'forward contamination'. Planetary protection protocols, though inconsistently applied, are critical to prevent cross-contamination, such as introducing Earth microbes to other planetary surfaces or returning extraterrestrial samples that might harbour alien organisms, underscoring the need for global adherence to safeguard celestial ecosystems. Meanwhile, terraforming or off-world colonisation risks ecological harm by prioritising human needs over environmental stewardship. Geopolitical tensions may arise from unequal spacefaring capabilities as resource extraction or territorial claims could mirror terrestrial power imbalances. Addressing these challenges demands international cooperation, equitable resource-sharing policies and transparent risk-benefit assessments to ensure space exploration and utilisation align with both scientific integrity and collective human interests.

45. Using radioactive materials as a source of energy, such as in nuclear power plants on the Moon or other planetary surfaces, presents both significant advantages and drawbacks. On the positive side, nuclear power offers high energy density: small amounts of fuel can generate substantial amounts of energy, which is crucial for supporting long-duration space missions and establishing sustainable colonies. Additionally, nuclear reactors can operate independently of solar energy, providing a continuous power supply regardless of planetary day-night cycles or weather conditions. However, the cons include safety concerns regarding containment and radiation exposure, particularly in case of reactor malfunction or accident, which could pose unknown risks to both human life and the environment. Furthermore, the logistical challenges of transporting radioactive materials, managing nuclear waste and ensuring compliance with international nuclear regulations add to the complexity and potential hazards of using nuclear energy on other planetary bodies. Balancing these pros and cons is essential for determining the viability of nuclear power as a sustainable energy source in extraterrestrial environments.

46. The unchecked expansion of Earth's electromagnetic emissions into space risks violating principles of cosmic stewardship because it may unintentionally disrupt the natural radio environment beyond Earth and potentially expose our planet to unknown extraterrestrial entities (Normier, et al., 2025).

47. The militarisation of space poses significant risks and harms, including the escalation of global tensions and the potential for an arms race beyond Earth's atmosphere. Deploying weapons in space could destabilise Earth's ecosystems and atmosphere, threaten international security, undermine existing treaties like the 1967 OST and increase the likelihood of conflicts extending into orbit. Additionally, the high cost of space weapons diverts resources from peaceful exploration, utilisation and technological advancement. Ultimately, space militarisation threatens the long-term sustainability of space activities, jeopardising cooperation and increasing the peril of catastrophic collisions or warfare in an already fragile orbital environment, and could irrevocably damage planetary environments. Further discussion on space militarisation is addressed in the forthcoming chapters.

IV.

NAVIGATING THE ETHICAL CONCERNS ABOUT SPACE EXPLORATION AND UTILISATION

48. The need for reflection on current concerns tailored to extraterrestrial contexts is indicated in this report as terrestrial norms may inadequately address unique challenges such as resource sovereignty, cosmic environmental harm or interspecies responsibility.

49. Without being exhaustive, this chapter explores specific ethical concerns that the Commission identifies in relation to space exploration and utilisation. It is entirely possible that additional concerns will arise in time and that there will be different emphases on some of the identified concerns in the future. The Commission therefore views this current discussion as a necessary starting point for ethical reflection on potential harms and risks related to space exploration and utilisation, rather than the last word.

Global participation

50. A first concern the Commission highlights is that space exploration and utilisation should involve fostering global participation and should prevent the marginalisation of certain countries or communities. The international community has been concerned about equitable access and participation in space exploration as far back as 1957, when the Soviet Union launched the Sputnik I satellite.

51. Nonetheless, inequalities and inequities regarding space exploration and utilisation exist. Currently developed and wealthier countries, as well as multinational private sector companies, dominate space activities more than developing countries. Similarly, there is low gender equity currently reflected in space endeavours. This means that space exploration and utilisation have the potential to create inequalities if privileged groups and countries continue to monopolise space exploration and resources. Thus, there is a pressing need to open access both to space and to deliberation on the governance of activities relating to space exploration and utilisation, so that there is shared multi-stakeholder space governance and fair distribution of space resources.

52. Ethical principles that arise in the context of this concern include equity and solidarity. Equity focuses on the fair distribution of opportunities, burdens and resources, while the principle of solidarity emphasises the interconnectedness of all humans and implies that particular care should be given to vulnerable and marginalised groups. A related principle is multi-stakeholder participation which implies that the governance of space activities needs informed engagement from diverse societal representatives.

Human capacity for well-being in peaceful surroundings

53. Secondly, there are ethical concerns in the context of space exploration and utilisation that relate to the human capacity for well-being in peaceful surroundings. These concerns include for instance space militarisation, lack of governance of space activities, lack of space access, unequal membership, questions of sustainability and security related to space debris, preservation of dark skies, potential 'colonisation' of planets (or asteroids) and its implications in terms of Earth governance systems and notions such as citizenship, environmental utilisation without exploitation of space resources and the portrayal of life in space as successful and peaceful by commercial entities.

54. The ethical principle that the Commission highlights in this context is the principle of transparency and openness. Everyone has the right to understand how space exploration and utilisation will impact the quality of their lives, their well-being and the potential for upholding international law. Ensuring this principle is upheld will require public awareness of and education on the above concerns and bilateral and multilateral deliberations on how to solve challenges that might make for political and social instability and exacerbate already existing inequalities (e.g. the U.S. State Department's framework for space diplomacy (2022), the EU Draft International Code of Conduct for Outer Space Activities (2014)). In this context, maintaining transparency and openness is a confidence-building measure which is part of a diplomatic toolbox that will ensure peaceful deliberation among states (Robinson, 2011). In terms of technological development, openness refers to several issues, including assuring access to gathered data and enabling open participation in the various stages of the development process. Transparency overlaps with openness and it also includes having explicit procedures and standards for various decision-making processes that are accessible to all and ensures accountability.

55. The prime reason why openness and transparency are emphasised in the development of new technologies is their deep connection to human and societal values. On the one hand, the direction of the development of new technologies often reflects the interests and values of those who are involved in the process. On the other hand, technologies may have much wider influence than the original developmental context, affecting people with diverse interests and values, and such influences are often received negatively by those people. To avoid such negative reception of technology, early intervention is essential and openness and transparency are prerequisites for such intervention. Furthermore, to build trust and prevent misunderstandings, early dialogue and cooperation are essential. The principle of openness and transparency, implemented on a cooperative basis and in a manner that respects basic human rights, is valuable for fostering international collaboration.

56. This general consideration also applies to space development. The future course of space development (including space mining, space environmental protection and space security, to name some) are partly determined by the values of those who are involved in the development, and the consequences of their decision-making may have impacts on those who are not involved, and especially those who have different values. In a sense, all of humanity who has gazed at 'the skies' are stakeholders of the night sky.

57. To detect, resolve or at least make progress on such value conflicts, the engagement of people with diverse ethical values is needed in space development, which calls for openness, transparency, accountability, verification and clarity. In addition, especially in security-related domains, keeping space activities transparent is key to encouraging mutual trust among space actors.

Intergenerational ethics

58. A third concern relates to intergenerational ethics, which focuses on the coordination of conflicts of interests among different generations, such as climate change mitigation, energy, food and water habitability, national debt or a sustainable insurance system. Intergenerational ethics form the basis of sustainable development, with the latter defined by the 1987 Brundtland report as "meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs" (UNGA, 1987). Addressing whether current generations have a moral obligation to safeguard the interests of future generations – and determining which ethical principles this question entails – presents several challenges in intergenerational ethics. One key difficulty is that conflicts of interest between generations cannot be resolved through democratic processes alone, given the inherent asymmetry between present and future populations. Since unborn generations cannot participate in decision-making, alternative ethical frameworks are required. Another challenge lies in determining the appropriate weight to assign to future generations' interests: should all generations be treated equally or is it justifiable to discount the concerns of the distant future? Despite these theoretical complexities, sustainable development remains a universally accepted principle globally and space development is no exception.

59. Principles that relate to intergenerational ethics in the context of space exploration and utilisation include proportionality, the precautionary approach and accountability. Proportionality ensures that any action that impacts individual members of society is justified, suitable, necessary and not excessive in relation to the objective being pursued. The precautionary approach mandates pre-emptive risk assessment to prevent harm. The principle of accountability speaks to holding those responsible for the impact of their decisions on society – and in this context, on space activities related to space exploration and utilisation – accountable, and is closely related to ensuring oversight.

Protection of space data and prevention of space piracy

60. Another concern relates to the protection of space data and prevention of space piracy, i.e. unlawful interference with space activities. As humanity's reliance on space-based infrastructure grows, so too does the risk of malicious interference such as unauthorised access to satellite communications, data theft or even the hijacking of spacecraft. Space piracy–whether conducted by rogue actors, corporations or state-sponsored entities–could disrupt critical services like navigation, weather forecasting and global communications. Legal frameworks such as the OST currently lack explicit provisions to combat such threats, highlighting the urgent need for international cooperation in cybersecurity, surveillance and enforcement mechanisms to safeguard orbital assets and ensure the secure use of space for future generations. In general, space data ethics concerns cover a broad scope given its wide-ranging applications, from scientific research related to environmental monitoring and agriculture, to logistics and communication, urban planning and national security (NSC, 2023). Space data is also collected from various sources which include satellites, telescopes, etc. (NSC, 2023).

61. Ethics principles that should be considered in this context include privacy and autonomy. In terms of privacy, a significant difference between data ethics and space data ethics is that while data ethics tends to focus on the rights of individuals, space data ethics' scope is wider and is linked to the dual use of space data (for instance, data on migration or environmental resources; NSC, 2023). Additionally, there is an underlying assumption in data ethics that individuals will have control over their data, while it is not clear what kind of say a state will have over its space data which may also be collected by a private entity. Urgent work needs to be done by multi-stakeholder groups on identifying wider space data concerns and potential harms related to space data (NSC, 2023).

62. The principle of autonomy in this context refers to safeguarding control of the spacecraft. This means that deep space exploration and utilisation require technology with appropriate autonomous capabilities. These would include spacecraft ability to respond to potentially anomalous and unforeseen conditions. This kind of response is for instance enabled through intelligent hardware and software sensing (Jonsson, Morris and Pederson, 2007).

63. Another autonomous capability pertains to planning and execution, which is closely connected to the uncertainties associated with space endeavours. These uncertainties are particularly evident when it comes to estimating the time required to complete specific tasks in space (e.g. telemetry travel time), as well as the resources needed–such as power and Central Processing Unit (CPU) time–to carry out those tasks (Jonsson, Morris and Pederson, 2007).

64. Further research is essential to define the boundaries and necessity of human oversight in the operation of autonomous AI spacecraft and to evaluate whether Earth-centric AI governance frameworks–often prioritising human control–remain appropriate for space environments. This assessment must account for the distinct technical constraints of deep-space operations, including communication latency and system resilience, and the ethical implications of AI-driven resource extraction and exploration beyond real-time human intervention.

Multi-species ethics

65. Another ethical concern relates to multi-species ethics. As humanity ventures into the cosmos, we must consider the potential impacts of our activities on extraterrestrial environments, microbial ecosystems and potential alien life forms. A multispecies ethic recognises the intrinsic value of all forms of life, whether terrestrial or extraterrestrial, and calls for responsible stewardship of planetary bodies and their ecosystems.

66. This approach entails preventing contamination, respecting the potential interests of possible non-Earth life and ensuring that resource utilisation does not harm existing or potential habitats. By adopting a multispecies ethics lens, humanity can ensure that space exploration and utilisation are conducted with integrity, fostering coexistence and respect for the diverse possibilities of life in the universe. Equally, the use of terrestrial animals in space exploration and utilisation raises ethical concerns like those in biomedical research, emphasising the need to minimise suffering and ensure necessity. Historically, animals have provided critical insights into the physiological effects of space travel, but their use must adhere to strict justifiable ethical principles.

Dual-use of space technology, space militarisation and the space race

67. Perhaps the biggest security concern in space exploration and utilisation relates to the dual use of space technology, space militarisation and the space race. One aspect of dual use is the problem of space debris. Space debris is basically anything humans have left orbiting in space on a planetary surface and can include even tiny specks of paint from a spacecraft. Low Earth Orbit has even been described as "an orbital space junkyard" (Nguyen-Onstott, n.d.). The speed and volume of space debris pose a risk to the safety of humans in space and on Earth, as well as to spacecraft. The problem is exacerbated by the low levels of governance and enforcement concerning space debris. (e.g. the European Code of Conduct for Space Debris Mitigation, 2004).

68. Technologies to remove space debris are currently in development, yet the proliferation of orbital debris remains a serious and growing threat, endangering satellites, human spaceflight and even terrestrial security. This issue highlights a tension between environmental and safety priorities on one hand, and military-strategic interests on the other. The current 'space race' unfolds in a governance vacuum, with both countries and private entities competing for dominance. The geopolitical 'scramble for the skies' raises profound ethical concerns, particularly regarding the militarisation of space. Complicating matters further is the rapid commercialisation of space which has sparked new resource races for helium, water, ice and other celestial commodities, adding another layer of conflict to an already contested domain.

69. Principles that address this concern are centred around peace and security, encompassing concepts of justice, solidarity and human dignity.

Environmental ethics

70. The presence of human-operated structures like the space stations underscores that space–or at least certain orbital regions–can reasonably be considered an environment, given humanity's growing interference with it. This perspective, however, remains contested in scholarly discourse (Reiman, 2009). A second, normative premise holds that humans are, to our current knowledge, the sole moral agents (and subjects) in space, entailing unique ethical responsibilities. Environmental ethics, traditionally applied to Earth, must now extend to the cosmos, evaluating humanity's moral relationship to the space environment, including its non-human elements, and interrogating the intrinsic value and moral status of celestial bodies and orbital ecosystems. This framework becomes urgent as human activities increasingly alter the space environment through debris, resource extraction and habitat expansion A transhemispheric perspective, among others, would afford us a deeper understanding of valuing space environments.

71. Consequently, there are different views on what should be seen as the most important environmental concerns and the related ethical issues and principles in relation to space exploration and utilisation. The annual number of rocket launches has been on an upward trajectory since 2005. These activities have direct environmental impacts: the amount of debris in space, for example, has grown to over 30,000 objects (ESA Space Debris Office, 2023), while increased space rocket launches contribute to atmospheric pollution, particularly when non-carbon-neutral fuels such as methane are used (Pierson 2021). In addition, contemporary rocket launches emit reactive chlorine, black carbon and nitrogen oxides (among other species), all of which contribute to damage the ozone layer (Brown, Bannister and Revell, 2023).

72. In relation to the protection and fragility of space, an important current focus is the near-orbital space around Earth, between 80 and 100 km above Earth's surface, and which includes the Low and Medium Orbital Space and the Geosynchronous Orbit. Activities and human artefacts in space are increasing environmental damage. This takes the form of cluttering, obstructing commercial, scientific and military activities and impacting public access to the sky by affecting its darkness and infringing on what could be seen as a right to 'an unpolluted night sky that allows the enjoyment and contemplation of the firmament' (IAU, 2009). A main challenge is the environmental damage – often incremental as each additional satellite launch can carry 25 satellites – and the fragility of space as a realm, both of which, like on Earth, are complex to assess and as with climate change and sustainability issues, are driven by many factors which contribute to the harm only partially but not solely. From a precautionary approach perspective, space needs to be treated as prima facie fragile. Space-related issues require environmental ethical reflection and engagement, with different pathways available to pursue these concerns, such as debris mitigation efforts like the 25-year deorbiting rule, planetary protection protocols to prevent biological contamination (e.g. Mars rover sterilisation), dark sky advocacy to reduce satellite light pollution and sustainable ISRU to minimise

Earth-dependent lunar operations.

73. In a broader sense, relating to the protection of the non-terrestrial environment such as the Moon, one question is how much of space and of the solar system we should leave as wilderness. One answer is that a one-eighth principle should be applied, that is only using one-eighth of space for extraction of some sort, based on an estimation of the growth rate for a space economy (Elvis and Milligan, 2019). The driving idea here is a commitment to adding quantification to space ethics in order to set targets, track impact, identify tipping points and consider trading-systems for space that comparable to those for carbon trading on Earth. This idea according to which ethical decisions must at some point rely on quantified data if it is to guide action has also recently resulted in the measuring of humanity's cosmic footprint (Normier et al., 2025). This may be particularly useful for the preservation of extraterrestrial landscapes. It dovetails with the landing points of this report—that space ethics should be "measurable and visible", for instance through the introduction of a space ethics scale (Appendix II), so that impacts, risks and benefits can be plausibly scaled. Determining whether one-eighth of the space environment and resources should be used while preserving the rest is a complex issue with no universally agreed-upon answer or scientific consensus. The concept of sustainability in space activities is becoming increasingly important, but the appropriate balance between resource utilisation and preservation is still being debated.

74. Concern for the environmentally sustainable use of space will become more pertinent as the Moon and in the future Mars become environments to be utilised as resources for human benefit. Any space mining is likely to use and disrupt the surface of celestial bodies. In addition, commercialisation raises issues of impact containment which are independent of the question of whether they are mineable. Therefore, some form of ethical consideration would indeed be necessary to establish limits on utilisation, and to determine how restrictive such limits would be.

75. From an intergenerational and sustainability perspective, this raises questions of what obligations the present generation on Earth should have toward future (human) generations. Utilisation of space suggests the 'tragedy of the commons' (Hardin, 1968) which sparked debate about restraint in the use of the natural environment. This concept points out that when many people enjoy unrestricted access to a finite, valuable and common environmental resource such as a pasture, there is a tendency to overuse it inadvertently end up destroying its value altogether if the use is not regulated, enforced or restricted. It could be argued that while restraints may be necessary in relation to the utilisation of Earth-based environments, the perception of space as an unlimited resource might lead to further overconsumption of Earth's resources (Nesvold, 2024). In addition, the equitable distribution of resources derived from space exploration is a key concern in space ethics: who should benefit from these resources and how should they be managed to ensure sustainable development for all? International cooperation and agreements are essential to prevent conflict and ensure that principles are established so that benefits are shared by all.

76. In approaching environmental concerns–whether through ethical reasoning based on maximising good outcomes or through rights-based arguments—one way of beginning to think more carefully about space environmentalism would be to consider the orbital space around the Earth as an additional ecosystem (Lawrence et al., 2022). It could be beneficial for present and future generations to implement the same broad regulations as those in place for the oceans and the atmosphere. Such regulations can be justified either by seeing space as having merely instrumental values to current and future generations of humans (an anthropocentric ethical worldview) or by affording space intrinsic value (a biocentric ethical worldview).

Uncertainty about the long-term environmental or biological impacts

77. Another ethical concern closely related to the above is uncertainty about the long-term environmental or biological impacts of certain space activities. A core principle here is the precautionary approach which mandates proactive restraint in space activities where scientific uncertainty exists. Examples include stringent sterilisation protocols for Mars-bound missions to prevent cross-contamination of potential ecosystems, restrictions on lunar mining in regions of astrobiological interest until ecological baselines are established and debris mitigation policies requiring satellite operators to deorbit defunct hardware within 25 years. This principle prioritises avoiding irreversible harm–such as disrupting pristine exoplanetary environments or depleting finite resources like lunar water ice over short-term gains, ensuring that exploration and utilisation proceed only when risks to cosmic ecosystems, scientific integrity or future generations are minimised.

78. Proactive measures can be taken even without complete scientific certainty about potential harm, in accordance with the precautionary approach.

79. The Rio Declaration (1992) and the UNESCO Declaration of Ethical Principles in Relation to Climate Change (2017) define the approach as follows: "Where there are threats of serious or irreversible harm, a lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects." The precautionary approach embodies the attitude of humility towards our current scientific knowledge. This attitude is especially appropriate when we enter new territory about which we have little knowledge, and this applies to space development. For example, we must take every precautionary measure not to destroy possible life forms on other celestial bodies, even before we obtain evidence for the existence of such life forms.

80. The precautionary approach can be formulated in various ways, though its stronger forms face objections. Theoretical challenges also exist concerning its appropriate scope and the minimal evidence required for implementation. Nevertheless, taking suitable measures in the face of uncertainty remains essential.

Space as a global commons

81. Lastly, a fundamental conceptual issue that has implications for a range of ethical concerns related to space exploration and utilisation is whether we should regard space as a global commons. The concept of 'global commons' refers to the need for collaborative regulation of shared resources. Such collaboration is meant to prevent the 'tragedy of the commons' which occurs in a situation where individual actors deplete shared resources for their own interests regardless of the future general harm to all resulting from such depletion.

82. The notion of space as a global commons, is rendered more complex by three basic perspectives on ownership in space. First, there is the view that space can be owned by some entities including countries, organisations and individuals. Let us call this the 'private ownership' view. The second perspective holds that space cannot be owned by any single entity because it is owned by humanity as a whole. Let us call this the 'global commons' view. The third view is that even humanity as a whole cannot own space. Let us call this the 'no ownership' view.

83. One could have a mixed position with different choices for different issues; for example, endorsing the 'no ownership' view for land on the Moon and other celestial bodies and the 'private ownership' view for the materials found on those bodies. It is also important to keep in mind that there are conflicting conceptions of space resources. These are clearly illustrated by the difference between the 'global commons' and the 'no ownership' views. On the one hand, according to the 'global commons' view, we can utilise space resources through formal global decision-making procedures. On the other hand, the 'no ownership' view argues that seeing elements in space as 'resources' is objectionable and that there should be strict limitations on what humanity can do in space, regardless of the decision-making procedure.

84. For some, the global commons approach is about shared property–resources that 'belong to all of us' –which are at risk of being appropriated and exploited by some, to the detriment of others. For others, this approach is about shared responsibilities to protect, manage and use common-pool resources for the benefit of all, not just for present generations and not just for humans, but also for non-human animals, the environment and the biosphere. From this perspective, the focus shifts from property rights to intergenerational justice considerations and related ethical principles such as respect for human dignity, transparency, openness and solidarity.

V.

COOPERATION FOR A GLOBAL GOVERNANCE FRAMEWORK

85. The discussion in the previous chapters highlights the debate over space as a global commons versus a private domain, coupled with ethical concerns over militarisation, commercialisation, resource utilisation, environmental issues and more, underscores the need for a robust and implementable global governance framework. Such governance is essential to prevent conflicts arising from the increased participation of countries and private entities, to establish fairness and equity in resource utilisation, to promote environmental stewardship of celestial bodies, to build trust through clear rules and accountability, to regulate technological advancements to ensure safety and ethical standards and to adapt rapidly to evolving technologies. Effective governance frameworks are crucial for fostering cooperation, ensuring responsible space exploration and utilisation and shaping a sustainable future in space. Due to the complex ethical issues involved, it is essential for all stakeholders at international, regional and national levels to cooperate. This cooperation is crucial for them to share responsibility through global and intercultural dialogue, promoting a collective approach to addressing ethical considerations in space exploration, utilisation and governance.

86. In that regard, the OST's assertion that space is the "province of all mankind" will remain aspirational without inclusive governance that reflects underrepresented states' interests. Emerging norms risk being shaped by a few, potentially sidelining principles such as equity, solidarity, privacy, autonomy, well-being, multispecies ethics, peace, security and others. For example, small island developing states, vulnerable to climate impacts, have stakes in how space intersects with terrestrial environmental justice and their participation legitimises decision-making and fosters accountability. An inclusive and enforceable governance framework would help to guard against such one-sided norms and to utilise the space for the true benefit of all humankind.

87. The foundations of this framework can be traced back to the early days of the Space Age. As concerns about equitable access and peaceful use of space emerged following the 1957 launch of Sputnik I, the international community responded by establishing the UN Committee on the Peaceful Uses of Outer Space (COPUOS) in 1958. This led to the adoption of the 1967 OST, which enshrined the principle that space shall be used for the benefit and in the interests of all countries, regardless of their level of development.

V.1. Regulatory framework

88. COPUOS helped negotiate major space treaties, including the OST and the Moon Agreement, which were later formalised into international law. It also provides guidance on matters such as space debris management.

89. Current space governance discussions begin with the existing legal framework. At its core lies space law, a branch of international law where treaties are the primary legal instruments (Lyall and Larsen, 2018). COPUOS has supported this legal development by negotiating major treaties such as the OST (1967) and the Moon Agreement (adopted in 1979 and became effective in 1984), and by issuing ongoing guidance on matters such as space debris mitigation.

90. The OST affirms that space shall be used "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" (Article 1). This ethical foundation is echoed in the 1986 Principles on Remote Sensing, which emphasise that remote sensing activities should benefit all countries, "taking into particular consideration the needs of the developing countries" (Principle II).

91. The OST also establishes that space shall be used for the benefit of all countries and prohibits national appropriation, however it leaves open key questions regarding the ownership and utilisation of space resources. In this context, the first national legislation that has emerged and that raises questions about compatibility with existing international frameworks includes the following two:

- **a.** U.S. Commercial Space Launch Competitiveness Act (2015): Allows U.S. entities to extract and own space resources under national jurisdiction.
- **b.** Luxembourg Space Resources Law (2017): Requires government authorisation for the exploration and use of space resources, while aiming to ensure peaceful and sustainable compliance with international law.

92. Beyond the OST, these instruments form the core of international space law, expanding on issues such as rescue, liability and transparency:

- **a.** Rescue Agreement (1968): Requires states to assist astronauts in distress and to return them, along with any space objects, to their country of origin.
- **b.** Liability Convention (1972): Establishes international liability for damage caused by space objects.
- **c.** Registration Convention (1975): Requires states to register objects launched into space with the UN.

93. A key challenge in space governance is balancing commercial ambitions with the collective stewardship of celestial bodies. In 2025, a proposal to designate the Moon as a protected site sparked debate under the OST's non-appropriation principle. While Apollo landing sites cannot be formally recognised as World Heritage Sites, initiatives like *For All Moonkind* advocate for their preservation as part of humanity's shared heritage. Scientifically, the Moon remains vital for understanding Earth's origins and regulating its climate. These developments highlight the need to revisit the existing legal framework–largely developed in the 1960s–to evaluate its capacity to address the evolving realities of space exploration, including emerging technologies, new types of actors and increased activity in space.

V.2. Ownership and utilisation

94. The different perspectives on ownership of space as introduced in the last chapter, namely the private ownership, global commons and no ownership views, raise an important question: Is space a global commons (i.e. a common-pool resource) or is it admissible to 'own' space resources privately? Or are these still Western ways of seeing the relationship between humanity and space? This is a fundamental question with serious policy and governance implications. Viewing space as a commons demands shared governance mechanisms and clear stewardship obligations. Conversely, private ownership models introduce risks of competition and conflict over sovereignty, access and control by individuals, companies and/or countries. If, on the other hand, we reject the terminology of 'resources' altogether, this will also call for an international cooperative framework, but the nature and purpose of the cooperation will be somewhat different, focusing more on a respectful attitude towards space. The current space imagination, dominated by prospects of ownership and commercial extraction, risks reframing space as a frontier for unethical utilisation, threatening dark sky preservation, equitable access and ethical boundaries.

95. The view that space 'belongs to all living beings'–the no ownership view–implies that individuals, commercial enterprises and countries have distinct obligations of responsible stewardship in relation to global resources–resources that lie beyond national jurisdiction. This requires collaborative, sustainable management of common-pool resources in space. This view is consistent with Article 2 of the OST. However, the Treaty would benefit from adding reflection on the interests, investments and initiatives of non-governmental commercial enterprises as the private ownership view threatens not only dark sky preservation but also the widening of existing inequality in terms of access to space and its resources.

96. A cooperative framework is essential to prevent conflict and ensure peaceful space exploration and utilisation. The OST bans weapons of mass destruction and claims of sovereignty, defining space as the "province of all humankind" (UNOOSA, 2023). The Liability Convention (1972) and Moon Agreement (1979) reinforce accountability, though enforcement gaps persist. Under Article VI, states are responsible for all national activities, including those conducted by private entities. As previously mentioned, ambiguities in Article II have led to divergent laws (e.g. in the U.S. and Luxembourg), allowing private resource appropriation and creating regulatory fragmentation. Dispute resolution remains diplomatic as bodies like the UN Office for Outer Space Affairs (UNOOSA) and COPUOS lack binding authority (Johnson, 2023). Private actors must comply with COPUOS' sustainability standards to avoid environmental and operational risks. The idea of space as a "global commons" implies shared ethical duties (Jakhu et al., 2022). International space stations offer the potential for geopolitical rivals to collaborate in orbit. To enhance governance, proposals call for empowering international bodies to oversee private activity under ethical rules and damage compensation mechanisms while preserving state sovereignty.

97. The OST ensures freedom of exploration but is silent on resource ownership, creating ethical dilemmas. It needs updating to address issues like asteroid mining and settlements. The OST affirms "free access to all areas of celestial bodies" (Article 1) and bans "national appropriation by claim of sovereignty" (Article 2), but omits mention of resource extraction, causing divergent interpretations.

98. The Moon Agreement goes further, declaring the Moon's surface and resources "the common heritage of mankind," barring property claims by states, organisations or individuals (Article 11). The Artemis Accords, meanwhile, allow resource extraction if aligned with principles like transparency and heritage preservation, differing from national laws such as the U.S. Commercial Space Launch Competitiveness Act (2015) and Luxembourg's 2017 law which permit private ownership of extracted resources. While these aim to spur innovation through legal certainty, critics argue they risk violating the OST's non-appropriation principle and deepening inequities. Proponents say they foster development without claiming territorial sovereignty.

V.3. Dual use and militarisation

99. The OST addresses militarisation explicitly. In Article 4, the OST prohibits the placement of 'any objects carrying nuclear weapons or any other kind of weapons of mass destruction' in orbit or on celestial bodies. Additionally, it prohibits the 'establishment of military bases, installations and fortifications' in space (Article 4). However, the OST does not mention conventional weapons or dual-use systems such as intelligent satellites.

100. It is important to recall that UNESCO's report on *The Ethics of Space Policy* (2000) highlighted a pivotal concern in the governance of space–one that remains highly relevant today. Technologies developed for civilian purposes, such as Earth observation systems, have significant military applications including surveillance, espionage and reconnaissance, while military-origin technologies like GPS have become indispensable in daily life, powering navigation, logistics and communication for civilians worldwide. This interdependence invites careful ethical reflection, aiming to minimise the risks of dual use technologies, which require ethical guidance and governance frameworks that promote accountability, accessibility and trust. Refer to the previous chapter for more discussion on the dual use of space technologies as an ethical concern.

101. Historically, major spacefaring countries have developed anti-satellite (ASAT) weapons, with some countries conducting kinetic tests as early as the Cold War–culminating in a controversial 2007 test which created thousands of debris fragments. Today, advancements in directed-energy weapons, co-orbital interceptors and electronic warfare systems blur the line between defence and aggression as countries increasingly integrate space capabilities into military doctrine.

102. Another important aspect is the long-recognised threat that meteorite impacts on Earth (NEOs and PHAs) pose to humanity. Over the past decades, space agencies and scientific organisations (e.g. the UN Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), the IAWN and the Committee on Earth Observation Satellites (CEOS)) have been researching various technologies to mitigate this danger. Different strategies have been proposed for deflecting a meteorite that threatens Earth, including kinetic impact propulsion, directed-energy lasers and the application of nuclear explosions. The dual use of technologies for meteorite deflection raises several ethical and security challenges. While protecting Earth from meteorite impacts is a global concern, the same knowledge and tools can be used for military purposes, leading to risks of geopolitical tensions and conflict escalation. The OST prohibits the use of nuclear weapons in space, but it does not specifically address the dual use of technologies for planetary defence. Moreover, the use of nuclear or laser technologies in space could have unintended side effects, such as the creation of hazardous space debris, which would increase the risk of collisions with satellites or even the space stations. Meteorite deflection technologies are promising tools for planetary defence. However, their dual-use potential poses significant risks in terms of international security, the militarisation of space and possible geopolitical conflicts.

103. The dual-use dilemma however extends beyond kinetic threats, with NEOs, satellite jamming, spoofing and cyberattacks already deployed in conflicts, demonstrating how civilian infrastructure can become both a tool and a target in geopolitical rivalries. Without updated treaties, these capabilities risk normalising space as a contested domain rather than a shared global commons.

V.4. Sustainability

104. Regarding environmental protection, the OST provides limited guidance. It states that the exploration of celestial bodies should be conducted 'so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter' (Article 9). Although COPUOS has addressed some environmental issues such as orbital debris, other critical concerns like the preservation of extraterrestrial landscapes or ecosystems remain unregulated at the international level. There is a growing consensus that voluntary principles are insufficient. Binding, enforceable rules are needed to manage contamination, land alteration and cumulative ecological damage caused by missions, mining and satellite congestion.

105. The preservation of celestial landscapes and ecosystems particularly on the Moon, Mars and other potentially life-hosting bodies demands urgent attention as current frameworks fail to safeguard these environments from irreversible harm. Similarly, the unchecked proliferation of satellites and space infrastructure threatens the integrity of dark skies, disrupting astronomical research and the cultural heritage of stargazing. Without robust, universally adopted standards, the long-term sustainability of space activities remains at risk, necessitating a shift from voluntary guidelines to legally binding agreements that address these multifaceted challenges.

106. Furthermore, the absence of comprehensive regulations governing resource extraction and land use in space raises ethical and practical concerns as competing interests could lead to ecological degradation and conflict over celestial territories. The international community must prioritise the development of equitable norms that balance exploration ambitions with the preservation of space as a shared environment to protect. Only through collective action and enforceable treaties can humanity ensure that the final frontier remains sustainable for future generations.

V.5. Governance, who governs and decides over space

107. As in many other areas of applied technology, the space industry has undergone a profound transformation due to the growing demand for access to space by new non-state actors, distinct from traditional government agencies, giving rise to the concept of "New Space". This wave has been driven by private companies accelerating innovation and lowering costs, particularly through the deployment of low-Earth orbit satellite constellations. As of 2024, a single company, SpaceX's Starlink, dominates the satellite landscape, accounting for nearly half of all operational satellites worldwide. With 6,111 active satellites, Starlink has approximately half of the 13,000 functional satellites worldwide, concentrating unprecedented influence in the hands of one entity.

108. The interplay between private innovation, public investment and regulatory gaps is reshaping space governance. As New Space continues its rapid development, transforming the space industry, governance proves to be crucial for maintaining a focus on sustainability, responsibility and equity.

109. Several international organisations address different aspects of space activities but none have a clear mandate to regulate the full scope of extraterrestrial activities. UNOOSA promotes peaceful space cooperation but lacks authority over commercial resource claims. COPUOS develops space law and environmental guidelines yet does not cover property rights or governance. The International Telecommunication Union (ITU) regulates radio frequencies and any associated orbits but not space resource use. Other entities like the Secure World Foundation and the Satellite Industry Association advocate for sustainability and industry interests, respectively but hold no regulatory power. This fragmented institutional landscape leaves major governance gaps in managing space resources.

110. Given this fragmented landscape, an ad hoc coordination framework could help unify efforts by UNOOSA, COPUOS and its action team on Lunar Activities Consultations (ATLAC), the Space Resources Working Group (SRWG) and other relevant bodies to govern space resource utilisation. This might require a new treaty focused on resource mining and ownership, establishing a legal regime that clarifies property rights, ensures fair benefit-sharing, enforces environmental safeguards and includes dispute resolution mechanisms involving non-state actors. Without such a unified agreement or at least international consensus, conflicts among space actors will persist, posing a major obstacle to sustainable governance.

111. One proposal is to negotiate new multilateral treaties focused on a wide scope of space activities. Another approach could be to form global coalitions to promote shared technology and equitable access to space benefits. Some experts have even proposed creating a dedicated international coordinating body, such as a 'Lunar Council', to oversee sustainability, though such an idea remains speculative and politically untested.

112. Alternatively, expanding the mandates of existing institutions like UNOOSA and COPUOS to address emerging challenges, including the regulation of private actors through their national governments, enforcement of legal-ethical standards and management of future issues like space migration and citizenship could be another option. This would enable the establishment of uniform standards for state responsibility, sustainability and equitable resource distribution. Achieving such reform requires inclusive, multicultural and multistakeholder dialogue involving governments, civil society, legal scholars and industry leaders. However, it is recognised that many states currently don't have governance in the space domain and this needs to be addressed.

113. Geopolitical tensions and private interests hinder binding governance, making consensus-based standards a pragmatic interim step. Yet, even standards risk capture by powerful actors unless pre-standardisation research is democratised and widely accessible.

114. Taking this into account, a new set of ethical principles, such as the one specified in section IV, is needed for space exploration since Earth-based norms may fall short in extraterrestrial contexts. Together, these principles aim to reconcile humanity's exploratory ambitions with the imperative to protect cosmic ecosystems and uphold universal dignity. They also align with governance values for emerging technologies, such as sustainability, proportionality, inclusivity, accountability and multi-stakeholder collaboration.

115. Planetary protection protocols enforced by national space entities are essential to prevent contamination during missions. Long-term habitability depends on sustainable infrastructure and ISRU. Ethically, inclusive governance–guided by Indigenous knowledge and Global South perspectives–can prevent monopolisation by dominant space powers. Binding agreements on demilitarisation, transparency and equitable resource-sharing are also vital. The Committee on Space Research (COSPAR) provides a forum for scientific dialogue and exchange that could facilitate further collaboration on planetary protection protocols.

116. Confidence-building in space requires transparency and cooperation through open data-sharing and traceable operations to prevent conflict and build trust among states (Johnson, 2023). Technologies such as blockchain may reinforce this by improving transparency and traceability in spectrum allocation and governance.

117. To address these challenges, a Global Space Fund could expand access and curb monopolies. Financed by state and private contributions, it would support research and technology transfer. A reformed COPUOS could govern it, promoting open standards and equitable participation. Given likely resistance from powerful actors, accountability tools like audits and penalties are essential.

V.6. Moving forward on space governance

118. Any regime of space governance grounded in extractive or proprietary logics–what some describe as cosmologies of "access by touching"–is unlikely to ensure planetary or interplanetary sustainability and could lead to irreversible harm. To avoid this, inclusive governance must address the exclusion of non-spacefaring countries through frameworks that grant them proportional influence in decision-making bodies like COPUOS. A global pre-standardisation fund, financed by contributions from spacefaring states and private actors, should support open research into sustainable technologies and ethical frameworks. Oversight must involve independent panels and rotating regional representatives, with transparency ensured through public audits. Compliance by private actors could be incentivised by linking access to markets and orbital slots with adherence to emerging standards, alongside tax benefits for collaborative research and development (R&D). All licences should include binding environmental safeguards such as debris mitigation quotas and liability clauses. This combination of inclusion and accountability would shift space governance from rhetoric to real stewardship.

119. As human activity moves from exploration to potential settlement, issues like migration and citizenship demand new legal and ethical frameworks. Although no formal regime currently addresses these topics, institutions like the UN, COPUOS and UNOOSA are well-positioned to lead. Future frameworks must guarantee human rights, prevent exclusionary policies and ensure that space settlements benefit all of humanity. The principle of space as a global commons offers a foundation for fair and inclusive governance in this new phase.

VI. RECOMMENDATIONS AND CONCLUSIONS

VI.1. Recommendations

120. Based on the above considerations, the Commission makes the following recommendations:

a. The challenges in a framework for peaceful space exploration and utilisation need to be addressed through strong international cooperation, agreements and implementable and enforceable governance, including the threat of space militarisation. Recognising that the UNOOSA plays a key role, the Commission recommends more multilateral committee dialogue (see COPUOS, 2025).

b. The precautionary approach should guide space actors in balancing the potential benefits of space exploration and use with the need to protect planets and all forms of life that may inhabit them.

c. Space-derived resources and innovations must be equitably allocated, ensuring inclusive global participation and access to both the benefits of exploration and use, and the knowledge it generates, with deliberate safeguards to dismantle potential monopolies and uplift historically marginalised communities. When determining admissible space usage, one must recognise that perspectives on space vary significantly; what one culture deems permissible, another may not.

d. Space activities need to integrate ethical considerations such as the degree of autonomy given to these systems (e.g. AI-Quantum decision-making autonomy) and the potential consequences of their actions.

e. It is necessary to acknowledge and encourage the value that space grassroots efforts contribute to the advancement, development and coordination of space activities.

f. The view that space is a global commons, or that nobody, including humanity as a whole, can own space, should be taken seriously, fostering peaceful exploration, equitable resource sharing and the advancement of collective knowledge for the benefit of all humanity. This would require enforceable transparency–such as open-access tracking of orbital activities and protection against space piracy–and accountability mechanisms, including binding agreements to penalise militarisation or environmental harm, ensuring collective stewardship for humanity's long-term survival. This involves clear reporting on the environmental impacts of missions and adherence to international agreements and regulations.

g. It is recommended to establish a Global Space Fund–financed by requisite contributions from spacefaring countries and private corporations–that would support transparent, collaborative research and education into technical, ethical and environmental benchmarks. To mitigate conflicts of interest, governance of such a fund would require multilateral oversight, possibly through a reformed COPUOS, with weighted voting power favouring emerging and non-spacefaring states.

h. While keeping in mind the complexities of governance structures explained in the chapter on Cooperation for a Global Governance Framework, the Commission recommends considering the use of communication tools, such as a space ethics scale. Space ethics is a complex field that could benefit from a synthesised tool of communication. The proposed space ethics scale could serve as an important communication tool designed to foster a common dialogue on the ethical dimensions of space exploration among all stakeholders and the public (see Appendix II for an example of such scale). Underpinning its use are core principles, including equitable resource access, international cooperation, the precautionary approach, fair benefit distribution, ethical AI integration, maintaining space as a peaceful domain and ensuring transparency and accountability in exploration activities.

i. Guidelines and an implementation roadmap could be developed by a UN-led expert working group, in cooperation with relevant space exploration and utilisation specialised entities such as COPUOS. This kind of collaboration would help incorporate a multidisciplinary and diverse range of perspectives and promote a more balanced and widely acceptable governance framework while engaging diverse stakeholders–including scientists, engineers, policy-makers, industry and the public–in a constructive global dialogue. These guidelines would also enable an ethics instrument such as the above-mentioned space ethics scale.

VI.2. Roadmap for implementing recommendations on peaceful and ethical space exploration and utilisation

121. This proposed 7-step roadmap emphasises collaboration, transparency and ethical stewardship, ensuring that space exploration benefits all humanity while safeguarding the cosmos today and for future generations.

1. Strengthen international cooperation and governance by:

- **a.** Convening a high-level UN-led summit involving the UNOOSA and multistakeholder committees to address gaps in existing frameworks.
- **b.** Developing a roadmap for revising, adhering to and harmonising international agreements (e.g. the OST, Moon Agreement, Artemis Accords and conventions and standards such as Planetary Protection Protocols) to reflect current challenges.
- **c.** Establishing a permanent international task force to monitor and update space governance policies (e.g. 'Lunar Council', 'Mars Council', etc.). And encourage countries to become members of the IAWN.

2. Apply the precautionary approach by:

- **a.** Creating guidelines for space actors to assess and mitigate environmental and ethical risks before launching missions.
- **b.** Developing a compulsory global registry for space missions, detailing their objectives, potential impacts, launch vehicle fuel type, risks (e.g. electromagnetic footprint), mitigation strategies, etc.
- **c.** Promoting research on the long-term environmental effects of space activities on celestial bodies and Earth's orbit.

3. Ensure equitable resource distribution by:

- **a.** Negotiating international protocols for the fair allocation of space-derived resources, ensuring access for both spacefaring and non-spacefaring countries.
- **b.** Establishing a global space fund, as suggested in the recommendations, to support capacity-building and technology transfer for countries with limited space capabilities.

   c. Promoting open-access platforms for sharing knowledge and innovations from space exploration.

4. Address ethical robotics, AI and quantum technologies integration by:
   a. Developing ethical guidelines for robotics, AI and quantum technologies in space missions, including accountability mechanisms and limits/delimitations on autonomy.
   b. Conducting global consultations with experts in AI ethics, space law and robotics to define best practices.
   c. Implementing mandatory ethical impact assessments for missions involving AI and robotics.

5. Promote peaceful and cooperative space use by:
   a. Strengthening confidence-building measures, such as transparency in mission planning and data sharing.
   b. Establishing a global space monitoring system to detect and prevent potential conflicts or militarisation.
   c. Fostering international partnerships for collaborative missions, emphasising shared goals and mutual benefits.

6. Enhance transparency and accountability by:
   a. Mandating regular reporting on the environmental and societal impacts of space missions, accessible to the global community.
   b. Developing standardised metrics for assessing mission impacts, aligned with international agreements.
   c. Creating an independent oversight body to review compliance with ethical and regulatory standards.

7. Develop and implement a space ethics scale (see Appendix II) by:
   a. Assembling a UN-led, multidisciplinary and diverse expert committee to formulate a space ethics scale, pilot it with global stakeholders, and integrate it into international frameworks for ethical decision-making in space, for instance UNOOSA and groups such as the Hague International Space Resources Governance Working Group. The committee will define criteria and guidelines for a space ethics scale, covering impact levels from minimal space activities and research to extensive resource extraction. Piloting the scale with governmental, corporate, and institutional stakeholders to refine its application, and developing guidelines of use and applications.
   b. Integrating a space ethics scale into international space governance frameworks as a tool for ethical assessment, communication and decision-making.

VI.3. Timeline for the 7-steps roadmap implementation

122. A proposed timeline for this 7-step roadmap implementation is divided into three phases as follows, from the moment of adoption:

a. Short-Term (1-2 years): Establish expert panels, draft guidelines and convene initial consultations.

b. Medium-Term (3-5 years): Pilot a space ethics scale, revise international agreements and launch capacity-building initiatives.

c. Long-Term (5+ years): Fully integrate ethical frameworks into global space governance, ensuring sustainable and equitable exploration.

123. As a species of explorers and users, we stand at the dawn of a transformative time in space exploration and utilisation, facing unprecedented challenges and opportunities. Regardless of our motivations for venturing beyond Earth, the rapid advancements in space technology demand a renewed focus on ethical considerations and innovative policy frameworks. Space ethics is essential to guide humanity's journey into the cosmos responsibly. It can help safeguard the space environment, foster peaceful international collaboration, and ensure that the benefits of space exploration and utilisation are shared equitably across all of humanity. By prioritising ethical principles, we can protect celestial bodies, respect potential extraterrestrial life and champion the sustainable and fair use of space resources, paving the way for a future where exploration uplifts and unites us all.

APPENDIX I: RECOMMENDED RESOURCES ON SPACE MISSIONS

Note that this list is a sample of websites, however given the dynamic essence of space activities, this list is not completely up to date.

- **Gunter's Space Page:** A meticulously maintained database of historical and current space missions, including commercial satellites, lunar missions and deep-space probes. It covers both government and private ventures.
  Website: https://space.skyrocket.de

- **Spaceflight Now - Launch Schedule:** Frequently updated website with real-time information on upcoming launches worldwide, including commercial missions (e.g. SpaceX, Rocket Lab, Arianespace).
  Website: https://spaceflightnow.com/launch-schedule

- **Next Spaceflight:** A modern, user-friendly platform tracking upcoming launches with crowd-sourced updates, and which focuses on commercial and government missions.
  Website: https://nextspaceflight.com

- **NASA Space Science Data Coordinated Archive (NSSDCA):** NASA's official repository for historical mission data, including international and some commercial missions.
  Website: https://nssdc.gsfc.nasa.gov

- **Jonathan's Space Report:** A detailed, text-based chronicle of all orbital launches, updated regularly since 1989.
  Website: https://planet4589.org/space/jsr/jsr.html

- **For commercial-specific tracking:**

  - SpaceX Missions
    Website: https://www.spacex.com/launches

  - Rocket Lab Manifest
    Website: https://rocketlabcorp.com/

- **Aggregated lists:**

  - Wikipedia List of Spacecraft (check sub-pages for uncrewed/commercial missions)
    Website: https://en.wikipedia.org/wiki/List_of_Starship_launches

  - For planned and upcoming missions
    Website: http://www.en.wikipedia.org/wiki/List_of_planned_future_spaceflight_launches

- **Example of grassroots efforts:**

  - **The Planetary Society:** A guide listing space missions organised by space object.
    Website: https://www.planetary.org/space-missions

  - **The CONFERS effort**
    Website: https://satelliteconfers.org/

APPENDIX II: PROPOSAL FOR A SPACE ETHICS SCALE

What is a space ethics scale?

The space ethics scale is a proposed communication tool which would offer a standardised framework to evaluate qualitatively the ethical implications of space activities, categorising them from low-risk scientific endeavours (e.g. spacecraft planetary fly-bys, data-sharing) to high-impact activities such as asteroid mining or permanent habitation, using parameters such as the likelihood and consequences of the activity.

Using a colour-coded system based on likelihood and consequences as well as symbols, the scale would intuitively communicate risks and uncertainties, akin to seismic or tsunami alert scales, fostering transparent dialogue among space agencies, policy-makers, industry leaders, scientists and the public.

The scale would prioritise principles such as environmental stewardship (e.g. contamination prevention), equitable resource sharing and accountability, with governance steps including stakeholder collaboration, regular audits and adaptive policies.

Designed for integration within bodies such as COPUOS, a space ethics scale would seek to align space development with global sustainability goals by balancing technological advancement with ethical safeguards. It would ensure that activities such as resource extraction or habitat construction adhere to shared guidelines that prevent monopolisation, minimise ecological harm and promote inclusive benefit-sharing.

As of 2025, no standardised tool such as a space ethics scale exists or has been formally proposed in the integrated, operational form described (i.e. a universal colour-coded system for categorising ethical risks across all space activities, akin to seismic or tsunami scales). While fragments of space ethics evaluation exist, a unified, actionable space ethics scale remains a novel proposal. Its closest parallels are hazard scales (e.g. Torino Scale for asteroids and NEOs) or Earth-focused tools (e.g. IPCC risk tiers), but none bridge technical risks with socio-ethical governance for space.

Parameters Definitions

- *Likelihood:* In a space ethics scale, 'likelihood' would quantify the 'probability' that a space activity (e.g. mining, habitat construction) will trigger an ethical breach, such as environmental harm or inequitable outcomes, based on technical, governance or contextual factors.
- *Consequence:* In such a scale, 'consequence' assesses the 'severity of impact' should an ethical breach occur, spanning environmental damage, socio-economic inequity, cultural harm and long-term sustainability risks across both Earth and space environments.

Next Steps

The immediate next step would be to collaboratively develop a comprehensive draft of the scale, integrating foundational ethical principles with practical space-specific scenarios. Following this, the draft scale would need to undergo rigorous validation and refinement through expert panels, stakeholder workshops and scenarios, with appropriate tests to ensure its applicability, clarity and robustness across diverse contexts in space exploration and utilisation.

Figure 1. Example of a space ethics scale

Levels and likelihood (%)	Number	Description	Consequence with governance frameworks
No consequence <80%	0	Robotic spacecraft flyby and orbiters, etc. Natural environment would not be damaged.	No impact by robotics or human exploration present or future.
Unlikely 60–40%	1	Rovers, atmos. probes, etc. Natural resources or environment would not be damaged.	Minor impact: further scientific justification would be required.
Maybe likely 40–60%	2	Landing spacecraft, drones/ helicopters, etc.	Medium impact; further scientific investigation would be required.
	3	Submersible probes, atm/liquid/ rock/soil sample return, etc. Adhere to space protocols (PPP).	Medium impact: natural resources or environment could be jeopardized; further investigation required.
	4	Risk/safety of manned spaceflight; unregulated commercial/private/ nongovernmental activities; debris hazards.	Medium impact: health hazards, contamination of Earth and space environment.
Highly likely 10–40%	5	Terraforming, space mining, human colonies, etc.	Large impact: affecting future exploration and habitation; scientific investigation required.
	6	Exploration for exploitation; permanent human colonies, etc.	Large impact: natural resources or environment jeopardized and/ or damaged.
	7	Discovery of bacterial life in the solar system.	Large impact: Niches for possible life forms may be present; damage can be mitigated.
Certain likelihood & consequence 0–10% or greater	8	Space mining on amino-acid–bearing asteroids; planetary mining; unethical megastructures; not adhering to space protocols.	Irreversible impact: scientific investigation required.
	9	Space militarisation (e.g. weapons in space); planetary-scale interventions.	Irreversible impact: would render object or planetary environment damaged for several years.
	10	Niches in space objects for possible life forms may be present.	Irreversible impact: irreversible damage to life and the environment.

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THE ETHICS OF
OUTER SPACE EXPLORATION AND UTILISATION

Space exploration and utilisation are entering a new phase. Once limited to observation, space is now increasingly accessed by a growing number of public and private actors. The rapid expansion of satellite activities, alongside emerging projects such as lunar settlement or asteroid mining, is transforming the space sector and raising important ethical questions. These developments and call for reflections, for example on the protection of extraterrestrial environments, the dual use of space technology or the fair distribution of benefits.

This report of the World Commission on the Ethics of Scientific Knowledge and Technology of UNESCO examines the ethical challenges linked to contemporary space activities. Grounded in ethical principles and informed by diverse perspectives, it offers concrete recommendations to guide Member States and all relevant stakeholders in ensuring the responsible exploration and use of space.

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