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Article

# Envisioning space crimes of tomorrow: Post-imaginaries and existence

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**Abstract:** The increasing complexity of space activities has introduced new challenges in categorizing and addressing crimes beyond Earth. These space crimes, influenced by unique environmental and psychological factors, require specialized legal expertise and innovative defense strategies. The harsh conditions of outer space and other planetary bodies add another layer of complexity to these issues. Despite their diversity, space crimes can often be classified using terrestrial crime definitions, though interpretations and justice methods may vary internationally. This research aims to explore the multifaceted nature of space crimes, influenced by factors such as environmental stress, emotional strain from family separation, constant safety concerns, and the nature of space occupations. The goal is to understand how these factors impact individuals' behavior and resilience in space. Recent incidents, like the alleged first crime in space involving NASA astronaut Anne McClain, underscore the urgent need for clear legal frameworks as space activities expand. With over 50 nations now engaged in space endeavors, the legal landscape for space crimes will continue to evolve, particularly with the growth of space tourism, militarization, and commercial activities. This study seeks to provide insights into the classification, causes, and potential solutions for space crimes, aiming to contribute to a safer and more regulated space environment.

**Keywords:** space crimes; legal frameworks; environmental crimes; international law; space activities; psychological factors

## 1. Introduction

The growing complexity of space activities has brought new challenges in defining and addressing crimes that occur beyond Earth. These space crimes, shaped by unique environmental and psychological factors, demand specialized legal expertise and innovative defense strategies.

Space activities cover a broad spectrum, including satellite deployment, space exploration, and commercial ventures like space tourism and resource extraction. The harsh conditions of outer space, such as microgravity, radiation exposure, and isolation, significantly affect human behavior and interactions. These factors, along with the vast distances from Earth, create unique legal and logistical challenges.

The extreme conditions of outer space and other planetary bodies add another layer of complexity to these issues. Despite their diversity, space crimes can often be classified using terrestrial crime definitions, though interpretations and justice methods may vary internationally (Arjun, 2020).

This research aims to explore the multifaceted nature of space crimes, influenced by factors such as environmental stress, emotional strain from family separation,

constant safety concerns, and the nature of space occupations. The goal is to understand how these factors impact individuals' behavior and resilience in space.

Recent incidents, like the alleged first crime in space involving NASA astronaut Anne McClain, highlight the urgent need for clear legal frameworks as space activities expand. With over 50 nations now engaged in space endeavors, the legal landscape for space crimes will continue to evolve, particularly with the growth of space tourism, militarization, and commercial activities (Carolyn, 2022). This study seeks to provide insights into the classification, causes, and potential solutions for space crimes, aiming to contribute to a safer and more regulated space environment.

## 2. Categorizing crimes in space

The emergence of extraterrestrial activity has introduced a novel challenge to the realm of criminal law. Traditional jurisdictional boundaries and legal principles are ill-equipped to address criminal acts committed in the vastness of space. Such incidents necessitate a specialized legal framework that can account for the unique conditions of the space environment. Several factors can contribute to criminal behavior in space:

- Environmental stressors: Exposure to microgravity, radiation, and confined living quarters can significantly impact cognitive function and emotional well-being.
- Psychosocial isolation: Prolonged isolation from family and friends can lead to diminished emotional stability and altered decision-making.
- Existential threats: The constant risk of accidents, equipment failures, and space debris poses a significant psychological burden.
- Occupational pressures: High-stakes decision-making under tight time constraints can exacerbate stress and increase the likelihood of errors.

To ensure justice and maintain order in space, we must develop robust legal systems that address these unique challenges. This includes establishing clear jurisdictional guidelines, crafting specific criminal codes, and implementing effective enforcement mechanisms. Additionally, a strong emphasis on psychological screening and support for space personnel is crucial to mitigate the risks of criminal behavior. By proactively addressing these issues, we can pave the way for a peaceful and law-abiding future in space (Soroka, 2023).

### 2.1. Terrestrial legal frameworks for space crimes

Common space crimes often involve physical altercations that lead to injuries or assaults in space stations and hospitality venues. Future scenarios could include public disturbances or organized crimes like terrorist attacks. These offenses generally involve the intent to cause harm, using excessive force, specific weapons, and strategic advantages. Quick reactions, self-defense, and escape maneuvers by victims are essential for safety. Criminal actions, whether planned or spontaneous, involve malicious intent and physical acts to cause harm, sometimes with the collaboration of others (Ennedy, 2021).

Philosophically, a criminal act represents a unity of behavior resulting in punishable outcomes, assuming the presence of mens rea (criminal intent). Minor

crimes in space might include verbal altercations, assault, theft, misappropriation, insults, or more severe acts like murder or sexual assault.

As space residencies, celestial hotels, private space stations, and commercial activities increase, new types of space crimes may arise. Policing, prevention, investigation, and judicial enforcement of these crimes present significant challenges, often criticized for their complexity and operational difficulties (Soroka, 2022).

In the microgravity environment of space, physical confrontations can have severe consequences due to the lack of friction and confined spaces. Injuries can be exacerbated by the difficulty of stabilizing oneself or others, and medical facilities may be limited compared to Earth. The potential for public disturbances or organized crimes, such as terrorist attacks, increases with the commercialization and habitation of space. These scenarios require advanced security measures, including surveillance systems, emergency response protocols, and international cooperation for law enforcement.

The use of weapons in space can be particularly dangerous due to the potential for breaching the hull of a spacecraft or station, leading to catastrophic depressurization. Strategic advantages might include knowledge of the spacecraft's layout, control over life support systems, or access to restricted areas. Training for astronauts and space residents includes self-defense techniques adapted for microgravity, as well as escape maneuvers to reach safe zones or secure areas within the spacecraft or station (Marazziti et al., 2022).

The concept of mens rea is crucial in space law, as it determines the culpability of individuals involved in criminal acts. Establishing intent can be challenging due to the unique psychological and environmental stresses of space. The enforcement of laws in space requires a combination of terrestrial and space-specific legal frameworks. International treaties, such as the Outer Space Treaty, provide a basis for cooperation, but the practicalities of policing and judicial processes in space are still evolving.

## 2.2. Crime enforcers

Crimes in space can be committed by various entities, including nations, space agencies, corporations, humans, or robots. However, robots operate based on preprogrammed behavior, so their "crimes" are usually due to program errors or digital bugs. Different rules apply to robots, and they cannot be punished like humans. Manufacturers and programmers often avoid liability due to exceptions and exemptions. For this discussion, we will focus on crimes committed by humans, regardless of their role, method, or location in space.

For instance, a state might be responsible for a poorly planned experiment causing contamination, such as the Israeli lunar module crash that possibly released hardy microorganisms on the Moon. This refers to the incident where the Israeli spacecraft Beresheet crash-larnded on the Moon in 2019, potentially releasing tardigrades, microscopic organisms known for their resilience. Another example is the USA spreading copper needles in space, causing pollution without international consultation, as advised by the Outer Space Treaty. This refers to Project West Ford in the 1960s, where millions of copper needles were placed in orbit to create a

reflective belt for communication purposes, which raised concerns about space debris. Negligence can also occur, such as allowing an unsanitized Tesla Roadster into space during a SpaceX rocket test. This happened in 2018 when SpaceX launched a Tesla Roadster into space as a test payload, raising concerns about potential contamination of other celestial bodies (Roesch, 2023).

States might also suppress scientific findings that should be shared under the Treaty, or fail to register space objects with the UN in a timely manner, violating the Treaty's mandates. The Outer Space Treaty requires countries to share scientific discoveries and register space objects to promote transparency and cooperation. Governmental space agencies might disregard the Outer Space Treaty or UN recommendations, leaving debris on the Moon or creating unnecessary space debris through ASAT (anti-satellite) tests. These actions, while not always explicitly prohibited, can have long-term impacts and safety hazards, making them near-crimes (Deplano, 2021).

Space law violations occur when entities fail to follow required precautions, as demonstrated by the launch of an unsanitized Tesla Roadster. Such actions result in the contamination of space and celestial bodies. Any entity-state, governmental agency, or private enterprise - bears responsibility for damaging the pristine space environment. Each violation of space law demands attention.

The threat of contamination extends in both directions. When returning spacecraft or capsules land in the ocean, they introduce space-based contaminants into Earth's waters and ice. The Russian spacecraft incident in Canada serves as a concrete example, where nuclear contamination likely occurred. The full impact of space-based pollution will only become evident through time.

## 2.3. Criminal behavior in outer space

The space environment poses distinct health challenges. Although the human body begins to adapt within a few days, this adaptation comes with negative effects. In the absence of gravity, bones lose density and muscles weaken, increasing the risk of injury, back pain, or fractures upon returning to Earth. These changes are similar to age-related degeneration, such as osteoporosis and muscle atrophy, but they occur much more rapidly in space. To counteract these effects, astronauts spend a significant amount of time exercising.

The vestibular system in the ears, which helps with balance and spatial orientation, becomes disoriented in microgravity. On Earth, this system relies on gravity to function properly, but in space, the lack of gravity makes it difficult to sense movement or orientation. This can lead to space sickness, which is similar to motion sickness, and can cause nausea, dizziness, and vomiting. Behavioral changes can also occur, potentially leading to conflicts among crew members.

Space travel also impacts the brain and behavior. Since the mid-20th century, space missions have shown that low gravity affects the brain, particularly the flow of cerebrospinal fluid, which cushions the brain and spinal cord. On Earth, this fluid flows under the influence of gravity, but in space, its flow changes, affecting the brain's physiology. Long-duration space flights can alter the fluid-filled spaces along

brain veins and arteries. Despite these changes, astronauts generally do not experience balance or memory issues, though the long-term effects remain uncertain.

The most significant health risks for space travelers include physical discomfort, biological changes, and mental stress during launch, zero-gravity conditions, re-entry, and landing. During launch, passengers endure intense vibrations and G-forces, which are the forces of acceleration felt as weight. In space, the body loses red blood cells, leading to anemia, a condition where there are not enough healthy red blood cells to carry adequate oxygen to the body's tissues. This condition can persist even after returning to Earth. Re-entry subjects the body to high G-forces again, which can cause visual disturbances or loss of consciousness.

These physical and mental stresses can lead to abnormal behavior, conflicts, and even crimes in space. For example, William Shatner, who traveled to space with Blue Origin in 2021 at the age of 90, described his experience as emotionally overwhelming, highlighting the profound impact of space travel on human physiology and psychology. Space travel is far from a simple journey and poses significant long-term health challenges.

## 3. Economic crimes in space

The classification and criteria for economic crimes in space can vary widely. At a basic level, these crimes might include the theft of personal belongings or valuable items from others in space. More complex offenses could involve the misappropriation of proprietary secrets from individuals or businesses, or the infringement of intellectual property rights related to space innovations. Intellectual property rights protect creations of the mind, such as inventions, literary and artistic works, and symbols, names, and images used in commerce. Future economic crimes might also involve unethical business practices in space travel and tourism, interference with lease agreements for the commercial exploitation of planetary resources, unauthorized encroachment on astro-property (property in space), or unlawful disruption of legitimate economic activities such as mining and manufacturing. Additionally, disputes over unsustainable leases or conflicting property rights on celestial real estate or infrastructure could lead to economic offenses in an increasingly competitive space environment (Sachdeva, 2023).

Another type of space crime could involve business or economic matters, such as disrupting authorized activities on celestial properties, actions harmful to business interests, espionage on sensitive research, or violations of intellectual property rights. Espionage refers to the act of spying or using spies to obtain secret information, especially regarding business or government activities. Space transportation and tourism, driven by profit motives, could also lead to various crimes. Tourists and guests might commit offenses, while space carriers (companies that provide transportation services to space) could engage in irregularities and compromises that amount to criminal acts. A critical aspect is the responsibility for the safety and security of guests, including assistance and evacuation in case of accidents or disasters (Sachdeva, 2019).

One notable case involving economic crimes in space is the NASA and Boeing Launch Services Fraud Case. The privatization of space launches in the early 2000s

led to a significant contract between NASA and aerospace giant Boeing. What began as an initiative to enhance efficiency and reduce government spending evolved into a cautionary tale of financial misconduct. Federal investigators uncovered evidence suggesting systematic overcharging, including questionable labor costs and payments for services never delivered.

A joint effort by NASA's internal watchdog and Justice Department officials revealed widespread irregularities in Boeing's financial reporting. The extensive audit exposed millions in questionable charges, culminating in a major financial settlement agreement. While Boeing resolved the matter without formal admission of misconduct, the case fundamentally altered NASA's approach to contractor oversight.

This incident reshaped space industry contracting practices, prompting NASA to implement more stringent financial controls and monitoring systems. The case demonstrates how traditional financial crimes can extend into space-related activities, highlighting unique challenges in overseeing complex aerospace contracts. These events catalyzed reforms in how government agencies manage and audit space industry partnerships, establishing new standards for financial accountability in space ventures (Johnson, 2021).

Space resource exploitation presents complex legal and ethical challenges as commercial entities eye celestial bodies for potential mining operations. International law establishes space resources as humanity's shared heritage, preventing any single entity from claiming exclusive ownership rights. Private companies cannot simply stake claims on extraterrestrial territories through occupation or presence, regardless of technological capabilities.

Any space mining venture must operate within a framework of global benefit-sharing. Companies pursuing resource extraction must establish transparent financial mechanisms, such as dedicated accounts for profit distribution among nations. This obligation extends beyond mere legal compliance—it represents a fundamental duty to the entire international community. Private enterprises entering the space resource sector must recognize their broader responsibilities, including ethical business practices and commitment to global development. These responsibilities align with modern corporate accountability standards and the principle that space exploration should serve humanity's collective interests (Sachdeva, 2019).

## 4. Crimes of international wrongs

Space exploration inherently involves significant human safety concerns that intersect with international law and human rights. The hostile environment of space presents multiple threats—from extreme temperatures and radiation exposure to lack of atmosphere and life-sustaining resources. As commercial space activities expand to include hotels, industrial facilities, and permanent settlements, protecting human life becomes increasingly complex. Workers and visitors in these extraterrestrial environments require robust safety systems, emergency protocols, and guaranteed evacuation options.

International space law establishes fundamental obligations for human protection beyond Earth. The core principles require nations to provide emergency assistance and support to all individuals in space, regardless of nationality or mission type. While

these protections were originally designed for government astronauts, modern space activity demands their expansion to cover commercial workers and space tourists. Nations authorizing private space ventures bear ultimate responsibility for their citizens' safety, including maintaining appropriate life support systems and ensuring safe return capabilities. This responsibility extends from initial launch through the completion of their space-based activities, whether planned or emergency departures.

Space law requires all parties to provide emergency assistance to anyone in distress during lunar missions. This includes access to facilities, vehicles, and other resources necessary for survival. The core principle establishes that all individuals on the Moon must be treated as astronauts deserving protection and aid, regardless of their national origin or mission affiliation. This framework builds on existing space treaties that govern rescue obligations and human safety in space (Deplano, 2021).

Organizations and authorities operating in space must prioritize human life and safety above other considerations. Any discriminatory practices or arbitrary decisions in providing emergency assistance would constitute serious violations of space law. Leaders and operators must follow clear, objective protocols when responding to distress calls or evacuation needs. Failing to provide aid based on bias or prejudice could be considered a severe breach of human rights, potentially resulting in loss of life. The interpretation and enforcement of these obligations requires strict adherence to humanitarian principles rather than subjective or discriminatory factors.

Any authority figure who endangers human life in space through negligent decisions faces serious legal consequences. International law provides frameworks for prosecuting those whose actions or inactions lead to harm, trauma, or loss of life in space environments. Such cases could be adjudicated through international courts, with penalties reflecting the severity of the offense. The isolation and inherent dangers of space environments make such negligence particularly egregious under humanitarian law principles (Deplano, 2021).

The expanding space workforce-from scientists in orbital facilities to mining personnel on celestial bodies-requires comprehensive protection under international agreements. While employment contracts may specify emergency procedures and safety protocols, fundamental human rights protections transcend these agreements. The Moon Agreement establishes non-negotiable safety obligations that participating nations must honor, regardless of commercial arrangements. These protections apply universally to all space-based personnel, ensuring their right to emergency assistance and safety measures cannot be compromised by contractual terms (Prashant and Suyash, 2024).

The interests of researchers working in orbiting laboratories, hospitality industry workers, and those involved in natural resource extraction and manufacturing on celestial surfaces are crucial. In cases of distress, accidents, or disasters, they might require local assistance for shelter or protection. Such situations and their remedies would typically be outlined in the employee's contract and mutually agreed upon. However, the Moon Agreement provides certain universal protections and safeguards against threats to human life that cannot be overridden. These international obligations bind ratifying member states and their representatives, regardless of contractual terms. Any breach of human rights or humanitarian considerations by responsible authorities would constitute culpable crimes under relevant national or international laws.

## 5. Categories of space criminals

The human mind remains the same even in outer space, and people can come up with many different ways to commit crimes. These crimes can be very serious, such as causing severe injury, murder, rape, or other major offenses. People can commit these crimes on their own, with others, or as part of a larger plan or group activity (Soroka, 2023).

Humans are social creatures, and sometimes they might do bad things when they feel they can remain anonymous, like during riots or when there is chaos and a breakdown of law and order. There can also be crimes related to business and contracts, such as cheating, fraud, breaking agreements, and violating intellectual property rights (which means stealing ideas or inventions). Additionally, there are crimes that involve technology. For example, using directed energy weapons (which are weapons that use focused energy like lasers), artificial intelligence, or cyber technology (which involves computers and the internet) to harm specific victims (Ireland-Piper and Freeland, 2020).

Another group of potential criminals includes private companies and businesses involved in space activities. These activities can include space travel and tourism, running space stations, mining resources from other celestial bodies (like asteroids or the moon), and maintaining infrastructure for space habitats (places where people can live in space), whether for tourists or permanent settlers on other planets.

These companies might also commit various legal violations, such as breaking contracts, interfering with the legitimate activities of others, getting into economic disputes, or engaging in espionage (spying) to steal business secrets or intellectual property (Soroka, 2023).

## 6. Future space endeavors

The nature of activities conducted in space will inevitably influence the occurrence of crimes in space. Historically, space missions were primarily aimed at scientific exploration and the discovery of new planets to expand human knowledge. However, this era has largely concluded or significantly diminished. Similarly, the focus on peaceful applications such as communications, broadcasting, and remote sensing has reached near saturation, with fewer new developments or groundbreaking applications anticipated in these areas. State-funded exploratory missions have experienced a sharp decline in budget allocations, further emphasizing this shift in focus.

Due to reduced government spending, existing infrastructures like the International Space Station (ISS) are being repurposed for commercial use or private operations, or they will be de-orbited and burned up in the atmosphere. Russia's plans are similar, and the European Space Agency (ESA) will have limited autonomy. The ISS faces an uncertain future as the US budget for its operation and maintenance is set to end by 2025. However, efforts are ongoing to secure resources by leasing the facility for commercial ventures or transferring ownership to the private sector.

Various potential uses for the ISS are being considered, such as transforming it into a movie set, using it for Earth-facing billboards, or converting it into a space motel for hospitality and entertainment services. The possibilities are numerous and remain

open for exploration. With the commercialization of the ISS underway, there are concurrent plans to develop additional space stations. China's initiative to build the Tiangong Space Station is advancing rapidly. As of October 2022, the Tianhe core module is centrally positioned, with the Wentian module on the starboard side, Tianzhou on the port side, and Shenzhou at the nadir. This space station will orbit at an altitude of 350 to 450 km, primarily serving research purposes, and will be continuously manned. Notably, China's drive to establish an independent space station was spurred by NASA's 2011 decision to exclude them from participating in ISS activities (Paladini, 2021).

With governments reluctant to invest in commercial space ventures and rapid advancements in space technology, a gap emerged that private enterprises have eagerly filled. Technological progress has made the commercial use of outer space and the extraction of celestial resources both feasible and profitable. For example, space transportation is quickly becoming a safe and cost-effective option. Companies like SpaceX and Virgin Galactic are leading the charge to offer zero-gravity experiences in low Earth orbit to paying passengers. Their regular commercial services could commence soon, potentially leading to scheduled trips to spaceports on celestial bodies.

The rise of space travel is set to boost the space hospitality industry. Initially, there is potential to refurbish the US module at the ISS, which is being offered for commercialization through private ownership or lease agreements. The US administration has already decided to reduce the budget for its operation and maintenance starting in 2028. Consequently, NASA plans to generate resources by gradually opening its ISS share to commercial opportunities and private use. The Inter-Governmental Agreement had anticipated such a scenario, allowing for activities like space transportation of personnel and cargo, space tourism, space advertising, and commercial experiments. Thus, NASA's strategy to lease out the American quarters at the ISS aligns with the legal intent and spirit of the agreement (Peng et al., 2024).

However, the lawful commercialization of the US module at the ISS introduces several unpredictable challenges in governance and management, including potential issues with discipline and law enforcement. Any country, commercial enterprise, or private entity can lease a portion of the ISS under agreed terms. Subsequently, personnel from the leasing entity or specialists hired from other countries may work together in the leased area. This space could even be transformed into a hotel offering unique and thrilling experiences (Weinzierl and Sarang, 2021).

Anticipated scenarios involving potential criminal activities, which carry international implications for jurisdiction and extradition, must be foreseen, understood, and legally addressed to ensure individual safety, societal harmony, and global peace.

The next wave of space activities is anticipated to focus on the commercial mining of mineral resources from asteroids and the Moon. Testing has shown that many asteroids contain rare minerals that are highly sought after on Earth. The extracted ore could be processed on-site, with the metals then transported back to Earth. Although the economic feasibility of such transportation is currently uncertain, advancements in rocket technology make this a plausible future endeavor. Additionally, the Moon Treaty allows for excavation, and mechanisms for benefit-

sharing among all states could be established in due course. The Artemis Accords of 2020 have already initiated steps in this direction, and any remaining legal issues can be resolved cooperatively as needed (Leonard, 2023).

The final anticipated category of space activities involves the construction of the Moon Village and Mars Colony, along with the necessary infrastructure to support hospitality resorts for tourists and livable residences for settlers who will become permanent inhabitants of these celestial colonies. Plans for these constructions and their support systems are currently being developed. Construction is expected to commence within the next decade or two, with residences and resorts featuring adapted living conditions becoming available within approximately twenty years, and potentially being inhabited shortly thereafter (Lee, 2012).

In discussing the nature of foreseeable space activities and their legitimate commercialization, several governance, management, and enforcement challenges become evident. These challenges include maintaining discipline, managing space workers, resolving business disputes, and enforcing law and order to ensure a peaceful and tranquil life for all residents. The space residents and workers will be multinational and multi-ethnic, which may lead to less than harmonious living conditions. Therefore, potential criminal contingencies with international ramifications must be anticipated, understood, and legally addressed to ensure individual security, societal harmony, international cooperation, and peace in space.

Certain space activities, casually mentioned in the discussion, involve breaches of the Outer Space Treaty. These breaches are noted with concern but lack clear definitions and emphasis on their severity. Consequently, the Treaty's narrative serves more as a recommendation to avoid such actions rather than a strict preventive measure. This vagueness in prohibitions may allow these activities to grow and spread, making it challenging to identify violations and enforce control through international cooperation or UN intervention. Specific issues include the militarization and weaponization of space, increasing amounts of space debris, and contamination of outer space and celestial bodies. Violations in these areas, whether intentional or accidental, could pose an existential threat to humanity, potentially causing irreversible damage. These should be considered crimes against all, requiring stricter initial controls. Although some violations have occurred in the past, there may be a future need to transform the Treaty's provisions into binding legal requirements with clear culpable elements (Mosteshar, 2020).

## 7. Crimes of the future

Certain space activities discussed involve violations of the Outer Space Treaty, an international agreement designed to ensure that space is used for peaceful purposes. However, the treaty's guidelines are often unclear and do not strongly emphasize the seriousness of these violations. As a result, the rules in the treaty function more as recommendations rather than strict prohibitions.

This lack of clarity and strict enforcement can lead to these questionable activities becoming more common and widespread. For instance, if the treaty does not explicitly forbid the militarization of space (using space for military purposes), countries might begin developing and deploying weapons in space, potentially leading to conflicts.

Similarly, if the treaty does not strictly regulate space debris (junk left in space from satellites and rockets), the amount of debris could increase, posing a danger to other spacecraft and satellites.

The vagueness in the Outer Space Treaty's restrictions could allow potentially harmful activities to grow and spread, making it challenging to maintain peace and safety in space.

### 7.1. Space militarization and weaponisation

Military strategists are likely drawn to the idea of militarizing space because it offers the strategic advantage of high ground for intelligence gathering and surveillance. In military terms, having the "high ground" means being in a superior position to observe and gather information about the enemy. The Outer Space Treaty (OST) does not explicitly define what constitutes military activities in space, but generally, these activities include those with military objectives, actors, and intended effects. However, the OST's prohibitive articles, which are meant to prevent certain actions, are weak and contain many loopholes. This means that the rules can be easily bypassed. Additionally, the treaty has permissive clauses that allow certain actions, which largely counteract the prohibitions. The Moon Agreement, specifically Article 3, does not impose stricter regulations either. Furthermore, the UN Charter acknowledges the Right of Retorsion (Article 51), which allows a state to retaliate against another state's illegal actions. Dual-use technologies, which can be used for both civilian and military purposes, are not prohibited in outer space, and their covert (hidden) and overt (open) applications are widespread and unchecked (Smith, 2023).

Regarding weaponization, the Outer Space Treaty (OST) also proves to be weak and ineffective. It bans the placement of any objects carrying nuclear weapons or weapons of mass destruction in Earth's orbit. However, a Russian experiment with a fractional orbital bombing system (FOBS) managed to bypass this restriction by only completing part of an orbit, rather than a full orbit as prohibited by the treaty. Despite this circumvention, the treaty was technically adhered to. Eventually, through negotiations, the Soviets responded to US objections and ceased further development and refinement of this project (Davies, 2021).

The Moon Agreement bans placing weapons in orbit around celestial bodies, installing them on the Moon, or using them in any way. It also forbids hostile acts and the testing of chemical, biological, or nuclear weapons in space. However, the vague wording and lack of clear definitions make it hard to enforce these rules. This means the current laws are not strong enough, and stricter rules are needed. Even a small mistake by a political group could have serious consequences for humanity.

The landscape of space militarization witnessed a pivotal moment when China conducted its first successful anti-satellite weapons test in early 2007. By destroying their inactive Fengyun-1C weather satellite using ground-based missile technology, China demonstrated advanced military capabilities in space warfare. This action triggered significant global repercussions (Neuneck, 2008).

The test's aftermath presented two major challenges. The immediate consequence was the creation of thousands of orbital debris fragments, establishing a persistent threat to operational satellites and space missions. Additionally, the

demonstration exposed critical vulnerabilities in space infrastructure, raising concerns about the security of essential services like global communications, navigation systems, and reconnaissance operations.

The global community's reaction centered on diplomatic protests and advocacy for enhanced space governance. This incident sparked renewed discussions about establishing robust international protocols to preserve space as a peaceful domain. The event serves as a crucial reference point in examining the broader implications of space weaponization and emphasizes the vital importance of collaborative international efforts to protect space assets and promote peaceful space exploration.

### 7.2. Space contamination and its repercussions

The creators of the Outer Space Treaty understood the risks of contaminating celestial bodies (like the Moon or Mars) with substances from Earth. They were also aware of the potential danger of bringing extraterrestrial viruses back to Earth. These risks are known as forward and backward bio-contamination. To comply with the Treaty's requirements, countries that engage in space activities have developed protocols (rules and procedures) for sanitizing and quarantining both objects and people involved in space missions.

Article IX of the Outer Space Treaty specifically states that countries must conduct space studies and explorations in a way that avoids harmful contamination of outer space. This means they should not introduce Earth-originating substances that could damage other planets or moons. Additionally, they must prevent any adverse changes to Earth's environment that could result from bringing extraterrestrial matter back to our planet. The Treaty also requires countries to consult with each other internationally before proceeding with any activities or experiments that might cause such contamination (Showstack, 2023).

Despite these proactive guidelines and procedural requirements, there have been instances where these rules were not followed properly. It is important to recognize that damage resulting from regulatory failures (not following the rules) or unsupervised actions (actions taken without proper oversight) may be irreversible. This means the harm could be permanent and could jeopardize the sustainability of the space environment, making it unsafe or unusable for future generations. Therefore, such reckless actions without adequate safeguards should be regarded as crimes against humanity, as they pose a significant threat to both space and Earth.

### 7.3. Private sector failures in protecting planetary environments

SpaceX, a private aerospace company founded by Elon Musk, was preparing for the first launch of its Falcon rocket. This rocket is capable of carrying a payload (the cargo it transports) of 37,000 pounds. Normally, for test launches, companies use heavy objects like steel or cement blocks to simulate the weight of a real payload (Wall, 2019).

However, Elon Musk decided to send his personal cherry-red Tesla Roadster, a type of electric car, into space instead. He called it the "perfect payload" because it could potentially stay in space for millions of years. This unusual choice was approved by the Federal Aviation Administration (FAA), which oversees and regulates all

aspects of civil aviation in the United States. Additionally, Musk placed a mannequin (a model of a human) named Starman in the driver's seat. Starman was dressed in a SpaceX spacesuit with logos and markings. There is some skepticism about whether specific FAA permission was obtained for the mannequin.

The decision to use the red Roadster as a payload received mixed reactions. Some people praised Musk as a visionary and innovative marketer, while others saw it as a publicity stunt, meaning it was done mainly to attract public attention. Despite the groundbreaking nature of this test launch, SpaceX did not follow recommended practices for Debris Mitigation and Planetary Protection. Debris Mitigation refers to measures taken to reduce space debris (junk left in space from satellites and rockets), and Planetary Protection involves preventing contamination of other planets and moons with Earth-originating substances.

The car, sent in its used condition, likely contained dust, grease, and other contaminants from Earth. If it crashes in outer space, these contaminants could pose a bio-threat, potentially harming the outer space environment. This action could be seen as "reverse panspermia," which is the idea that life or biological material from Earth could spread to other parts of the universe. This could violate Article IX of the Outer Space Treaty, which requires countries to avoid harmful contamination of space and celestial bodies.

As of August 2019, the Falcon rocket carrying the Roadster and Starman mannequin had completed its first orbit around the Sun. Scientists estimate that this "space-load", if it remains intact, could continue orbiting for over three million years. Given the numerous uncertainties, sending the car as cargo was not considered a prudent decision, even for personal satisfaction. The US authorities also failed in their duty of authorization and supervision under Article VI of the Outer Space Treaty, which requires countries to ensure that their national activities in space, including those by private companies, comply with the treaty (Rummel et al., 2012).

### 7.4. The dangers of space-based nuclear testing

The late 1950s saw the emergence of nuclear experimentation in space, as Cold War tensions drove scientific advancement. In 1958, the U.S. military conducted Operation Argus, testing nuclear detonations at high altitudes above the South Atlantic. The scientists hoped to replicate the protective functions of the natural Van Allen Belts - regions of charged particles trapped by Earth's magnetic field that shield against solar radiation. While they succeeded in creating an artificial radiation zone, it proved too unstable to maintain long-term effectiveness (Wolverton, 2012).

Four years later, Operation Starfish Prime marked an escalation in atmospheric nuclear testing. The detonation of a massive thermonuclear device in the Pacific skies created unprecedented electromagnetic disruption. The blast, occurring 400 kilometers above Johnston Island, caused widespread electrical failures throughout Hawaii and impacted systems as distant as New Zealand. Beyond these immediate effects, the test permanently altered Earth's radiation belts and electromagnetic environment, demonstrating both the power and consequences of high-altitude nuclear explosions (Wolverton, 2012).

The global community was shocked by this reckless experiment, conducted without consulting the scientific community. This led to a collective realization that such activities needed to be halted immediately to prevent further escalation in the space race between the superpowers. To curb nuclear testing, the Partial Test Ban Treaty was signed in 1963, banning high-altitude nuclear tests among other restrictions. Shortly after, the Outer Space Treaty came into effect in 1967, prohibiting nuclear weapons in outer space under Article IV. The Moon Agreement of 1979 also included similar prohibitions on nuclear activities on celestial bodies.

Space exploration faced a significant environmental challenge in 2012 when a Russian space mission went awry. The Phobos-Grunt probe, carrying a substantial amount of nuclear fuel, failed to achieve its planned trajectory and fell back to Earth. While officials minimized the environmental concerns, the probe's breakup over the Pacific Ocean between South America and New Zealand raised serious questions about the risks of nuclear-powered spacecraft. The incident highlighted the potential dangers when space missions carrying radioactive materials fail.

That same year marked a contrasting success in nuclear-powered space exploration when NASA's Curiosity rover began its Mars mission. The rover's innovative power system converts plutonium's thermal energy into electricity through specialized batteries, enabling its extended operation on the Martian surface. While environmental studies indicate minimal immediate risks from Curiosity's nuclear components, the broader question remains about the cumulative impact of increasing nuclear-powered missions in space. As more spacecraft employ radioactive power sources, the potential for environmental consequences—whether through equipment failure, accidents, or gradual deterioration—demands careful consideration (Liz, 2022).

### 7.5. Nuclear waste in the cosmos

Although the placement of nuclear weapons and the conduct of nuclear tests in outer space are prohibited, international space law allows the use of nuclear power sources for satellite energy needs, provided certain principles are adhered and it complies with international law. This is because, for some space missions, nuclear power sources are particularly advantageous or even essential due to their compact size, longevity, and other beneficial characteristics. However, the inherent risks associated with these materials and the increasing amount of debris orbiting in space remain a concern.

During negotiations, the US representative suggested that these Principles should serve as safety goals rather than imposing arbitrary dose limits, which have not been linked to accidents. Despite this stance, the USA did not block the Committee's consensus to forward the Principles to the General Assembly for resolution adoption. However, the delegate expressed concerns during the GA debate, stating that the principles "do not yet possess the clarity and technical validity needed to ensure the safe use of nuclear power sources in outer space." He further asserted that the USA's approach to these issues is technically clearer and more valid, highlighting the country's history of safely and successfully applying nuclear power sources. He emphasized that this approach would continue. Regardless of the merits of this

approach and manufacturing practices, the primary goal of the principles is overall safety, which can best be achieved by clearly defining usage limits from all perspectives (Venturini, 2020).

Research conducted in the mid-1980s revealed the growing presence of nuclear materials in Earth's orbit. At that time, scientists documented nearly 50 nuclear-powered satellites, containing significant quantities of radioactive elements including uranium-235 and plutonium-238. Analysis projected these orbital nuclear materials would triple to approximately three tonnes by 2000, with potential for exponential growth reaching ten tonnes by 2100. The extremely long decay period of these materials—particularly uranium-235's 700,000-year half-life—presents long-term risks of radiation exposure to other spacecraft and potential contamination of space and Earth environments (Venturini, 2020).

The danger of nuclear-powered satellites is not theoretical—history has documented several concerning incidents. Between 1964 and 1982, multiple spacecraft carrying radioactive materials experienced failures, including the Transit satellite (1964); Nimbus (1968); Apollo 13's power unit (1970); and two Soviet Cosmos missions (1978 and 1982). Each incident demonstrated the real possibility of nuclear materials re-entering Earth's atmosphere and dispersing radioactive debris. These events validate concerns about the increasing use of nuclear power sources in space missions (Power and Arn, 2018)

A significant incident in this context is the fall of the Soviet Cosmos-954 satellite on northern Canadian territory on 24 June 1978. Launched on September 18, 1977, this satellite carried a nuclear reactor enriched with uranium-235 isotopes. It experienced an uncontrolled descent from orbit, entered Earth's atmosphere, disintegrated, and scattered radioactive debris over Canadian soil. A claim for damages was made under the 1972 Liability Convention, and the matter was negotiated and settled for C$3,000,000 in 1981 (Power and Arn, 2018).

The main point is not about the value of the claim The main point is not about the value of the claim or how it was settled, but to highlight that the radioactive debris had a minor impact because it fell in uninhabited areas and caused no deaths. If it had landed in a densely populated area, the damage and potential deaths would have been much worse, posing serious disaster management challenges. Therefore, it is important to consider how much nuclear material an orbit can safely handle before it becomes dangerous.

Pollution from space debris is a pressing concern. An example is the descent of nuclear-exposed debris, such as the Russian Cosmos satellite, which landed in Canada, highlighting the associated risks. Such events could occur anywhere, including over oceans or polar regions. Although we may not yet fully grasp the scope of space pollution, it has the potential to become a significant problem in the future.

Implementing sensible regulations is a better approach than allowing unrestricted freedom for every space-faring agency to launch and operate nuclear-powered satellites under the Treaty. Given the significant amount of nuclear fuel already in space, the potential damage caused, and the ongoing support and permissive rules, it's crucial to recognize the harm done and the future threats. While we cannot undo past mistakes, we can start now to create a safer future for the next generations.

## 8. A comprehensive evaluation

In summary, human behavior will extend into outer space, leading to various crimes. Space crimes present several legal challenges, including jurisdiction over the accused, extradition issues, procedural laws for prosecution, the competence of domestic courts, applicable laws and punishments, and perceptions of justice.

The absence of a specific code for space crimes will become increasingly problematic as private operators engage in space travel, tourism, and mining. Dubious activities in this competitive and profit-driven environment are inevitable, and this scenario may arise sooner than expected. As the saying goes, to be forewarned is to be forearmed.

To meet its treaty obligations, the USA has a special provision in its Code for criminal conduct in space and other non-territorial areas. This "special maritime and territorial jurisdiction" covers handling criminal complaints outside national jurisdiction. It primarily addresses serious crimes like murder and assault but can serve as guidelines. For lesser offenses like hacking, the law is less clear, especially in incidents involving multiple nationalities. If a US citizen is harmed in a private space hotel with other international passengers, the situation becomes complex. Governments would need to consult for a solution, but prolonged disputes may lead the aggrieved party to seek remedies under their national jurisdiction.

International treaties are state-centric and do not recognize individuals as legal subjects. Under space law, liability for damage or injury caused by an individual falls to the state level. The launching or controlling state is responsible and liable, jointly or severally. The responsible state can reclaim liability from the other state or take action against the offender under domestic law.

Relying on state sovereignty for justice is ineffective for individuals, as diplomatic solutions are often slow and unsatisfactory. Clear procedures and simplified jurisdiction are essential because justice delayed is justice denied. The widely reported case of Anne McClain underscores the need for timely international action and negotiations. We have the opportunity to address properly and promote peace among space travelers.

Internationally wrongful acts, as defined by "the Articles", violate international treaties and can be tried in courts like the ICJ or ICC. While this framework is useful, it is not immediately applicable since no breach of space law or treaties has occurred.

Anne McClain's alleged misfeasance demonstrates intent and knowledge of consequences, establishing prima facie culpability. However, the complainant's more serious wrongs diluted McClain's culpability. This case is straightforward, involving one state, but future space crimes may be more complex, making jurisdiction difficult for national courts.

Many complications can arise both internationally and domestically. Moot courts have explored complex scenarios with international and national implications. One potential issue is human rights violations in space, such as the refusal to provide aid during emergencies. The Moon Agreement mandates such aid, and denial would be punishable under relevant laws, upholding human dignity and legal principles.

## 9. Conclusion

The domain of outer space activities is set to become more competitive and conflict-prone as nations transition from peaceful commercial endeavors to strategic military goals. Private companies are swiftly entering the space industry, focusing on lucrative ventures such as space transportation, hospitality, logistics, and resource extraction.

These activities will introduce unique challenges and require innovative solutions, potentially leading to new types of crimes with complex jurisdictional issues. In the case of Anne McClain, no international laws were breached, and jurisdiction lies with the US courts due to the astronaut's nationality and the location of the incident. Thus, the US courts have legitimate jurisdiction.

Future space crimes could be complicated by the ownership of space objects by the launching state and the involvement of private operators from various nations. This complexity necessitates proactive protocols to manage such dilemmas. The nature of crimes and their impact on victims will vary globally, complicating jurisdiction and extradition issues. While crimes like bodily harm may be straightforward, intellectual property theft and public disorders will pose significant challenges.

As space activities diversify, future crimes may involve technological and cyber elements, complicating legal solutions. The militarization of space adds further complexity, highlighting the need for methods to minimize space crimes. New definitions and solutions in space law are required, possibly through a protocol to the Outer Space Treaty or a new treaty on space crimes. However, negotiating a new treaty may be challenging. To address these challenges, several concrete recommendations can be made:

1) Structure and jurisdiction of an international tribunal for space crimes
    - The tribunal could be composed of judges from various countries with expertise in space law, international law, and criminal law. It should have a permanent secretariat and be supported by a team of legal experts, investigators, and technical advisors.
    - The tribunal's jurisdiction could cover crimes committed in outer space, including but not limited to piracy, unauthorized appropriation of space resources, and acts of aggression. It should also have the authority to adjudicate disputes between states and private entities involved in space activities.
2) Revisions to the Outer Space Treaty (OST)
    - Amend the OST to provide clearer definitions of liability for damages caused by space activities, including those involving private companies.
    - Introduce provisions that regulate the extraction and use of space resources, ensuring that such activities are conducted sustainably and benefit all humankind.
    - Establish stricter guidelines and responsibilities for the mitigation and removal of space debris to prevent collisions and ensure the long-term sustainability of space operations.
3) Roadmap for the creation of a dedicated international space court

- Phase 1: Conduct a comprehensive study to assess the need, potential structure, and jurisdiction of an international space court. This study should involve stakeholders from governments, international organizations, private sector, and academia.
- Phase 2: Develop a draft statute for the space court, outlining its mandate, procedural rules, and enforcement mechanisms. Engage in multilateral negotiations to refine and adopt the statute.
- Phase 3: Formally establish the space court, appoint judges, and set up the necessary administrative and operational infrastructure. Promote awareness and understanding of the court's role and functions among space-faring nations and entities.

A governance institution for outer space and resource management is essential, possibly through the revival of the UN Trusteeship Council. Furthermore, an International Court of Space Crimes could handle specific disputes and justice requirements. By implementing these recommendations, the international community can better prepare for the legal complexities of future space activities.

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## Treaties

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