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My God, it's full of robots! – Lunar industrial robotic operations from the perspective of space law.

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1. INTRODUCTION

The exploration of outer space and celestial bodies is frequently referred to as a pinnacle of human goals and achievements. From the search for native life forms beyond Earth[1], studying the composition of planets[2], asteroids[3], and comets[4], to discussing human settlements on the Moon or Mars[5], and even discussing long term goals referred to in Kardashev scale[6], it is seen as a set of achievements for human civilization and post-terrestrial societies[7]. However, the majority of the exploration and utilization endeavors are being carried out by machines. Satellites, probes, robotic landers, rovers, and servicers have been delegated to carry out the bulk of the work. Contrary to many early futuristic visions, earth observation, telecommunication, and on-site investigation are not performed by astronauts or humans[8]. Projects focused on testing in situ space resource utilization (ISRU)[9] and in-space manufacturing (ISM)[10] are robot-based. The first ship to leave the solar system[11] is not a sleeper ship[12] carrying explorer teams in suspended animation or an enormous generation ship[13], fitted with an ecosystem fit to sustain the primary crew and their future settler progeny[14]. The task of being the envoys of mankind has been technically passed down to ever more complex and advanced human artifacts[15]. Thus we are closer to the concept of sending out Bracewell probes[16] by another name[17], which would establish remote outposts, industrial bases, and supply depots on other planets[18] than sending astronaut-workers for the same purpose[19]. This state of the matter can be explained by the general instability of long-term crewed9 space exploration, due to political factors and the risk factors related to human presence in outer space. Another factor contributing to robotization is the advancement in electronics, and materials engineering, such as miniaturization[20], telecommunication, power and thermal management, machine autonomy, and structural design. Designing a robotic space explorer or worker requires less mass consideration, and there are no requirements regarding designing its inner space with humans in mind[21]. One needs only to recall The Golden Age and New Wave science fiction stories, where crews of space freighters[22] carrying cargo between constantly moving ports and stations in the solar system were basically moving

homes, where in some scenarios whole families were employed and spent most of their lives[23]. Not to mention communities of asteroid miners making their lives on remote minor bodies in the solar system[24].

Why it may seem that robotic space explorers and workers are ruining the romanticism or the excitement of space endeavors[25], they aren't free from failure, risk, or posing legal as well as policy questions. This is why human-robotic cooperation[26] and human-oriented systems are still at the center[27] of the lunar and Martian program. Humans working with remote teleoperators[28] and utilizing AI for the purpose of hab system management[29] and human safety show[30] us that there is still a need for a human in the loop. This is with a visible shift in position and tasks towards robots and automated systems[31].

While we might be familiar with the idea of space technologies spilling over into different fields of science and engineering[32] or becoming the base for consumer commodities on Earth[33], terrestrial developments impact space exploration as well. Similarly with developments in synthetic biology[34], which can be seen in projects relating to extraterrestrial biomining[35] and ISBM[36], the advent of machine learning technologies, commonly referred to as Artificial Intelligence is increasingly influencing robotic space projects[37], in fields of robot autonomy[38], data processing in space[39], software-defined satellites[40], and even programmable matter[41]. This however creates further challenges to the already heavily strained framework of international space law. The main framework of international space law has not been updated since 1975[42], with the Moon Agreement of 1979 failing to achieve broad ratification due to the provisions regarding space resources[43]. The main reason for its limited adoption was the rejection of its ratification by the US Senate in 1980[44], following the lobbying of a number of space-oriented NGOs[45], mainly the L5 Society[46] and the National Space Institute[47]. While there have been calls to amend the Agreement[48], the US President's Executive Order 13914 on "Encouraging International Support for the Recovery and Use of Space Resources."[49] further reinforced the position of the United States on the topic[50]. However, developments in the form of intergovernmental project-specific contractual laws[51] and implementation of *soft laws* and recommendations implemented within national space laws can allow for particular legal clarity on certain issues[52]. Nevertheless, these cannot be viewed as replacements for the international treaty system, with which they ought to comply, though they sometimes seem to supplement[53].

The main legal challenges with regard to large-scale implementation of space robots in outer space are as follows. The first issue is authorization and supervision over multirobotic operations[54]. The second is the issue of jurisdiction and control over mining, manufacturing, and servicing operations, as well as over robots manufactured in situ. The third is the liability and responsibility for robots and their activity. Those are followed by conclusions to the presented work.

2. SPACE OBJECTS UNDER SPACE LAW.

Space objects can be viewed as the astrolegal and astropolitical appendages of spacefaring states, with which they carry out space activities[55]. A space object comes into being however not by the means of launching it into outer space[56] or landing on the surface of a celestial body, but rather by its entry into the state's registry of space objects. Furthermore, international space law seems to be facing a conundrum of a lack of proper definition of space objects[57]. This is additionally impacted by national space regulations and practices in regard to space object registration. Some spacefaring nations differentiate between a number of potential space objects, such as space stations, space vehicles, or satellites[58], while others regard only specific devices as space objects, leaving small sats out of the category and denying them entry into their national registry[59].

Taking into account the provisions of the Outer Space Treaty of 1967 (OST)[60], space objects are considered to be artificial, mobile quasi-territorial jurisdictions of their states of registry. The mobility of space objects relates not only to the propulsive systems they are fitted with, as in the case of satellites and launch vehicles, including Last Mile Delivery (LMD)1 and Orbit Transfer Vehicles (OTV)[62] but to the basic provisions of Article II of the OST. The non-appropriation principle of the OST permeates the understanding of surface and subsurface space stations and installations as artificial structures not fixed to the ground and therefore not constituting the means or the basis for creating land rights or real estate[63]. Thus they are treated as movable or removable from their present position. Their presence doesn't imply any extension of national jurisdiction or basis for claims of sovereignty towards their surrounding area. Similarly, an accidental or purposeful impact site does not create landed rights towards the debris area, though the ownership of the debris remains unchanged by the event. This stems from Article VIII of the OST, which also underlines the quasi-territorial status of space objects carried on the national registry[64].

The act of entering a space object into the national and UN registry implies the authorization of space activity the object is destined to carry out, however, it needs to be recalled that the authorization may fall into the imperium of different bodies of national administration[65]. Therefore the act of authorization of a space activity should be a prerequisite for registration of a space object, though the authorization might cover several space objects and operations throughout a planned mission. Furthermore, The entry of a space object into the national registry may come due to the change of ownership of the object already present in outer space[66], or due to the succession of states[67].

This in turn takes us back to the issue of the space objects as moving boxes of national space activity[68]. These boxes not only contain within them the national jurisdiction of the state of registry, and the concept of the application of the complete set of national regulations in their interiors – their structure is permeated by the national jurisdiction in particular fields of law[69]. For example, in the case of patent law – the solar sail might be an integral component of the registered space object, as well as

a technology piece protected by patent in the jurisdiction of the state of registry (as well as other jurisdictions where the patent has been granted)[70]. Therefore the solar sail becomes both the embodiment of a protected invention as well as the area of patent protection in the quasi-territorial jurisdiction of the registered space object. This involves the operation of its mechanisms, the composition of the object as well as, if applicable, the processes and operations that the object undergoes or is used to achieve as a whole. The space object is the means of national space activities, therefore the laws don't only govern its interior, its structure but also the use of its external components and instruments in their interactions with outer space, the surface of celestial bodies, and if required, other space objects (national or foreign). It is the scope of authorization that metaphorically drives the actions of a robotic rover, the operations of a satellite, and a servicing vehicle[71].

There is also a need to address the fact that space exploration, along with space resource and manufacturing activities will include (as means, tools or products) unconventional space objects. Many of them would be either modular and reconfigurable robots, while others could take the form of smart dust[72], utility fog[73], or robotic matter[74]. Programmable matter and reconfigurable robots[75] are different from software-defined robots and satellites, however pose some challenges to the space object registry. Chief among the problems is that activities involving them in the manufacturing ecosystem would include the idea that the modules that formed the original space object might have changed their function or become elements of a new space object. Thus there will be a nuance involved in keeping track of these objects. On the other side of the issue, we have very small space objects that could proliferate with dust blasts or stick to third-party space objects[76]. Nanosats, picosats, and chipsats have already been deployed, however, similar small objects haven't yet deployed beyond GEO. Projects utilizing laser sail propelled chipsats have been proposed[77], yet legal issues will arise with the deployment of smartdust-like systems on the Moon. Smartdust and programmable matter can be useful in sensor-based monitoring and exploration, and as elements of larger industrial structures[78], yet the problem of deploying very small space objects involves carrying them in a proper registry. Keeping track of tiny space objects will be extremely hard, though the deploying state will remain liable and responsible for any damage or interference they might cause.

Thus even though one could view national space law as limited to the space objects themselves, in practice, the space object can be seen as a metaphorical eyestalk[79] or an appendage, through which a nation-state performs acts of space activity. This analogy only highlights the matter of geocentrism of international space law and astropolitics[80], yet it further allows us to see how space objects affect outer space and celestial bodies during their activities. It is not unreasonable to view decommissioned, damaged, or otherwise inoperational space objects as discarded elements of the "national organism"[81] extended into outer space. This space object derived "detritus"[82] however cannot be perceived as the equivalent of "marine snow"[83], as much as humans would love to extend nautical analogies into outer space.

3. SPACE RESOURCES AND IN-SPACE MANUFACTURING

Going back to our "appendage" analogy, space objects interact with outer space and celestial bodies according to national space law, upon authorization, within the framework of international space law. This includes objects involved in space resource activities[84]. In the absence of an internationally acceptable framework[85] for space resource operations, several state parties to the OST have decided to allow authorization of space resource activities within their national space law[86]. Space resources are also present in intergovernmental project-specific contractual frameworks, such as the Artemis Accords[87] and the ILRS project[88]. There are numerous independent propositions for regulating space resource activities on the international level, none of which have yet gained international recognition[89].

It should be noted that not many approaches to regulating space resource activities recognize the value of in-space manufacturing[90] as a strategic and operational advantage[91] for improvising and adapting to unforeseen situations[92]. This comes mostly from the misunderstanding of concepts like space mining[93] or ISRU[94], as well as the history of the space resources debate within the field of international space law[95]. There are ongoing debates that revolve around the idea of the scope of the non-appropriation principle present in Article II of the OST, as well as the idea of "ownership" regarding resources (both extracted and within their natural deposits)[96]. Introducing ISM into the debate provides clarification over the idea of the use of space resources and branches out into a different question: *What is the legal status of the products of ISM, which were manufactured using extracted space resources?* Currently, there is no definite answer, though several proposals have been produced in national space law[97], as well as in academia[98]. As ISM activities can be divided into intravehicular and extravehicular operations[99] It would be reasonable to accept that products of ISM created from or with the use of space resources will have to fall into two categories. One is space products, which are basic tools, articles of manufacturing, replacement, and spare parts, that are insufficient in their purpose and use in order to be registered as space objects. The second are "space object"-grade products, which have been manufactured with the use of space resources, and assembled on-site, and designed specifically for use in outer space in a manner similar to conventional space objects. These would include launch vehicles, OTVs, rovers, surface and subsurface structures such as crewed stations, and solar panels. While the latter might pose a challenge to space law, as they are not "objects launched into outer space"[100] per se, both can serve as the basis for discussing the scope of authorization and the operator's business autonomy. However, we need to recall that some space products might be manufactured around and assembled with core space objects launched from Earth, thus becoming components of space objects in the process[101].

It is reasonable to assume, that by authorizing space resource activities, the US government grants the designated person the right to "*to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States.*"[102]. However, the scope and limitation of the right to use and sell those resources are still unclear. The use might include processing the resource into fuel, coolant, or potable water, while it may also include acts of manufacturing tools, articles of manufacturing, and

structural elements of larger objects and vehicles. It is uncertain how much liberty would be granted to the authorized entity with an established space resources operation with regard to post-extraction activities. Business entities engaged in space resource activities would be interested in a more *laissez-faire* approach, where authorization and supervision regard only the basic safety and standard compliance of the extractive and manufacturing activity. That way they could manufacture products or sell products on the national or international markets without obstructive state intervention. However, an Earth-based micromanagement akin to strategy games of the 4X genre[103] is also possible. With regards to authorizing states protecting their interest and national security, it is possible that initially every product manufactured for the commercial market and not for the purpose of a state-directed space program will require authorization and constant supervision from the proper government body. This partially resembles the commercial space remote sensing dilemma, where restricting the use of satellite data limits business applications[104], while also maintaining government leverage over products of a dual-use technology and mitigating risks to national security[105]. One may imagine government entities establishing a tier system or categories for space resources and manufacturing with their use, where certain objects such as basic supplies or articles of manufacture including standardized spare parts are subject to minimum restrictions, where "strategic space resources"[106], such as platinum group metals, rare earth elements or isotopes (including Helium-3) require a specific license and more rigorous supervision. Manufacturing operations utilizing strategic space resources, or the manufacturing of robotic rovers and structures on the surface of celestial bodies will be more restrictive, especially with regard to the ability to sell manufactured vehicles, systems, and structures to foreign entities[107].

4. AUTONOMOUS SYSTEMS AND SPACE MANUFACTURING.

Autonomous systems for space mining and manufacturing have been a topic of study for several decades[10]. Lunar factories[109], multi-robot swarms[110], and even possible self-replicating factory systems[111] utilizing lunar or asteroid resources have been discussed either generally or in great detail. The ability to maximize space resource utilization to the point of self-replication[112] can be seen as a pinnacle of the mining and manufacturing system[113]. While the difference between a closed mechanical ecosystem[114] and the proper industrial capacity of lunar factories[115] will remain technical and philosophical questions, space law has to wrestle with different ones.

We need to recall that all initial elements of the space factory complex will be launched from Earth and therefore be recognized internationally as space objects under Article VIII of the OST. This "seed factory"[116] will be designed to extract local resources in order to produce designated pieces of equipment and build desired structures. Thus, a group of space objects that collectively create the initial factory will in time create new objects, as well as spare parts for existing ones, with further copies of the original objects down the line. Thus we can say that a space factory is "*a space object or a group of space objects, possessing a manufacturing capacity or which are used for in-space manufacturing activities*". This would include dedicated industrial space objects, such as processing facilities, stationary and mobile processing and manufacturing machines, haulers, transporters, cargo and resource depots, as well as crewed and uncrewed space objects of general purpose, fitted with manufac-

turing equipment (robotic arms[117], 3D printers[118]) and used for the purpose of in-space manufacturing. In our case, these would all comprise either remote teleoperators or autonomous systems.

Adding autonomous systems to space operations further complicates the situation regarding the provisions of international space law[119]. While we can simply disregard any possible prohibition of placing Artificial Intelligence in outer space under the notion that it may be classified as a weapon of mass destruction[120], the fact that international space law treaties are ill-fitted for regulating autonomous space robots remains. The provisions of the Outer Space Treaty form the fundamental framework for human activities beyond Earth. Yet, they were not created with complex autonomous robotic systems in mind[121]. With debates in the field of space law still revolving around the basic topics such as demarcation between air space and outer space[122], and the more recent topics like non-appropriation regarding space resource activities[123] and the pressing issue of mounting number of space debris[124], one can see AI as another element to push international space law into its own Kessler collision cascade[125].

First and foremost, is the Article VI of the OST. States wishing to employ autonomous systems in their space activities will be required to set up provisions for authorization and means of constant supervision and bear responsibility for the acts of the authorized entities. The problem here includes the question of the nature of the system – *Where is it based? Is it a lunar central computer remotely operating all of its robot swarms?*[126] *Or is the system located on Earth, with the on-site central system being only a peripheral node, carrying out tasks directed from the Earth-based system*[127]*?* If it's the latter, the issue arises with some systems being spread out over multiple jurisdictions[128]. With that regard, we need to recall that formally, under Article VIII of the OST, the state of registry retains the jurisdiction, as well as control over its space object. However, how much control does the state have over an autonomous system in outer space[129]?

Here we unfortunately run into a problem of space practice that has shaped international space law. Currently, all space activities are controlled from the surface of the Earth by designated mission control centers (MCC)[130] and other bases of operation[131]. This directly ties them to both articles VI and VIII of the OST, where direct control of a space object remains in the proverbial hands of state-based or private entities, supervised by appropriate governing and supervisory bodies of the state[132]. Utilizing an Earth-based AI system would necessitate that the authorizing state put forward sufficient requirements for the entity applying for license[133], ensuring compliance with the national autonomous system or AI laws[134], as well as means of maintaining supervision over the space system it's operating[135]. These intersections of national AI laws and space regulations have not yet been established, although low-level autonomy has been employed in orbital satellites and to a certain extent, rovers[136]. The "in-space computer core" concept[137], where the *in-situ* central computer provides connected machines with instructions and is able to act with a high level of autonomy presents a greater challenge. Though it is reasonable to assume that future space operations carried out by robots in deep space will benefit from a local controlling computer due to latency issues experienced by direct command from Earth[138], the

state that granted the license and authorized the operation will be held responsible for actions of the robotic nest and its drones[139].

This might be seen even as a paradox, concerning that space objects registered by a state are, as discussed earlier, acting as appendages and quasi-territorial jurisdictions of the state of registration. Thus a scenario where the concerned state has limited or no effective control over its robotic space objects begs question of the basic mechanisms of authorization (supervision and responsibility) as well as control in the understanding of space law[140]. The problem mirrors two problems discussed in works of space law. First is the problem of space debris[141], where Earth-based control over a launched object is lost due to malfunction, loss of propellant[142], or impossible due to the nature of the object itself. The second is the speculated idea of the legal autonomy of remote human settlements on Mars.

The example of space debris however relates not to the responsibility of states for the activities of its nationals, and government entities, including remote teleoperators and autonomous space objects, but to liability for damage and collisions caused by space objects[143]. Launching states, which can be different states from the current state of registry of space objects, are liable for damage caused by their space objects, whether on Earth or in outer space[144]. This topic has been discussed in relation to applications of Artificial Intelligence in space activities, for collisions with space objects and their fragments might be the result of decisions and actions of AI systems[145]. However, it needs to be stated that while AI systems can be embedded within the systems of the autonomous space object, the registration convention and space law in general treat only tangible objects as space objects[146]. In relation to our space mining and manufacturing operations, it might be difficult to differentiate responsibility from liability in some areas. Creating harmful interference does not qualify as causing damage *per se* under the liability convention[147]. The most obvious example would be rovers driving into third parties' space objects directly[148]. However, it is possible that acts of harmful interference that cause indirect physical damage (such as blowing clouds of abrasive regolith) could be considered physical damage under the liability convention. Furthermore, rovers physically acting upon third parties' space objects, in the form of moving, removing, or disassembling or otherwise appropriating their components could be the basis of both a liability claim and appealing for state responsibility for its space objects and authorized activities[149]. It should be noted, however, that these "robot vandals" need to be registered as space objects if they have been manufactured on-site. Yet, even if they are registered as a space object equivalent (space-made product, space-manufactured object)[150], they might be missing a launching state assigned to them[151]. In terms of liability, it may be reasonable that the state should be wary, that even if its locally produced robots are not considered space objects, the seed factory most likely will be. Thus by extension, the state might be viewed as responsible for any violations of international law performed by the products of its authorized and registered space factory.

The second example of discussed autonomy for Mars settlements includes several factors.

The first factor is that Martian space stations would be made up of several cooperating modules that are not physically connected to one another. They are only a

cluster of quasi-territorial space objects. A similar case can be seen in satellite constellations, where states exercise power over the moving objects in outer space, and not the areas between said objects. The case for Martian autonomy or the broader discussion over applying space law to remote settlements brings us to the problem of introducing autonomy into responsibility under Article VI. Initial objects that form the core of Martian settlements are landed and constructed space objects and, thus are linked to the terrestrial state of registry. The personnel also falls under the jurisdiction of the proper state on the basis of their nationality, authorization, or the space object they inhabit or use while on a celestial body. A number of concepts have been presented, ranging from expanding national regulations[152], proposing an international[153] or multinational governance[154], and creating Mars-specific regulations[155]. Other works highlight the problem arising from the efforts of Martian settlers in gaining legal autonomy[156] and problems stemming from the astropolitical practice in creating and adapting new acts of space law[157], or Mars-oriented international organizations[158]. Space environmental concerns might be raised by recognizing the rights of Mars itself[159]. However, the main issue arises when settlers start developing their own policies regarding settlement, technology, or the use of the Martian environment[160]. Outside of the concept of ecoforming, such as ecopoesis and terraforming, Martian settlers will require limited operational and decisional autonomy in regards[161]. There have been concepts of martian constitution presented in space law as well as in science fiction[162]. However, here lies the problem of space law: *at which point does a state lose its responsibility for operating space objects (and their personnel)?*

From the Martian settlement perspective, it seems that the idea of autonomy, sovereignty, and independence is based on the historical experience of populations, especially colonies. While one might doubt that similar attempts towards liberation and political emancipation carried out by robots would be viewed with similar understanding[164], in the case of humans the alternative is political and social rigor that might run contrary to the idea of human rights[165]. Therefore there is a level of acceptance for states to be relieved of responsibility for the actions taken by human settlers in deep space, despite their founding infrastructure being comprised of state-linked space objects and thus legal obligations.

The analogy of Martian independence concepts creates additional pitfalls for discussing autonomous industrial systems in outer space. On the same note presents the paradox of states waiving their jurisdiction, control, and responsibility over distant space objects, if they are acting "autonomously" via its inhabitants. This shows that under certain, though hypothetical circumstances, a state can renounce its international responsibility for activities it has previously authorized and withdraw any supervision. By that, the state would also surrender the jurisdiction and control of given space objects to a newly formed politically autonomous party. This runs contrary to the contemporary approach towards space debris, as they cannot be scuttled or legally abandoned[166] (declaring them res nullius), as well as the international obligations of the state regarding Article VI. Within the contemporary understanding, the state will retain jurisdiction and control, as well as bear responsibility for actions, which would include the unauthorized proliferation of space objects or space manufactured objects. It will, also under the contemporary framework, be held liable for damage caused by space debris, including inappropriately operating space objects,

whether the issue is caused by the AI control system or faults in the manufacturing and assembly process.

Thus the concept of In-space Computer governance over the operations of autonomous systems will require the development of novel instruments of space law, or at least space law adjacent. It is doubtful this will take the form of an international treaty, or instruments of soft law for national regulators to implement in the national framework. However, following the frameworks of the Artemis Accords and the ISS IGA, it is possible that the "contractual" route for space regulations regarding specific operations would be a better solution. Taking into account how diverse national and regional regulations on AI and space law tend to be, a multinational agreement with an open access system would seem proper. However, as with propositions on creating a "space jurisdiction"[167] under the governance of an international entity, astropolitical tensions might turn any such contractual framework into another moon treaty[168]. For now, it is up to the national and regional governments to regulate autonomous systems in outer space – and adding the whole packet upcoming of lunar industrialization can lead to different autonomous industrial space systems existing on the same celestial body, but in different parallel worlds of the space law multiverse. Thus making it a labyrinth of legal frameworks, through which any party seeking legal remedies needs to traverse, which would involve multiple planes of international private law.

5. CONCLUSIONS

What can break a space lawyer's heart is that the development of space technology goes down a path that international treaties cannot follow. At least under their contemporary framework. The body of international space law will have to undergo intense upgrading, with new instruments and an updated understanding of contemporary problems and issues looming on the horizon. The inclusion of autonomous robotic systems with ever-growing manufacturing capacities will gradually hollow out the contemporary framework, or the absence of new issue-specific regulations is going to eat away the technological potential, by nerfing possible advancements. While this is not uncommon in the field of space development theory, where evolutionary factors and "great filters" are considered as selection mechanisms for both life, artifacts, and civilizations in outer space (or the galaxy), unreasonable prohibitions will only hinder robotic space utilization and expansion of the human sphere beyond Earth. However, lax developments will create a hostile wasteland for new space actors, with irresponsible entities running rampant and unrestrained say by their resources and the environment. Therefore states and private stakeholders need to take into consideration the mid and long-term effects of regulations - possibly creating novel approaches in the process.

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[20] Instytucja założona w 2009 r. z inicjatywy Instytutu Astrofizycznego Wysp Kanaryjskich, w celu promowania astroturystyki. Od 2011 r. przyznaje certyfikaty miejscom spełniającym kryteria Fundacji.

ABSTRACT:

ENG: Robotic space exploration allows humans to perform space activities remotely in the hazardous environment of outer space and celestial bodies. And where robots go, the law should follow. However, taking into account that the majority of treaties that make up the framework of international space law are at least 50 years old, numerous problems tend to unfold. This includes issues relating to the authorization and international responsibility for robotic space objects, especially ones granted higher levels of autonomy. Regarding the near future experiments and activities focused on mining space resources and manufacturing products beyond Earth, there are serious concerns raised, that are not easily addressed by the contemporary framework of space law. This article aims to describe problems stemming from robotic space manufacturing and employing autonomous systems for that task through the lens of space law.

PL: Robotyczna eksploracja przestrzeni kosmicznej pozwala ludziom na zdalną działalność w przestrzeni kosmicznej w niebezpiecznym środowisku przestrzeni kosmicznej i ciał niebieskich. A tam, gdzie podążają roboty, powinno podążać prawo. Biorąc jednak pod uwagę, że większość traktatów tworzących system międzynarodowego prawa kosmicznego ma co najmniej 50 lat, pojawiają się liczne problemy. Obejmuje to kwestie związane z udzielaniem zezwoleń na działalność oraz międzynarodową odpowiedzialnością za działania robotycznych obiektów kosmicznych, zwłaszcza te, którym przyznano wyższy poziom autonomii. W odniesieniu do przyszłych eksperymentów i działań skoncentrowanych na wydobywaniu zasobów kosmicznych i wytwarzaniu produktów poza Ziemią, pojawiają się poważne obawy, które nie są łatwe do rozwiązania przez współczesne regulacje prawa kosmicznego. Niniejszy artykuł ma na celu opisanie problemów wynikających ze zrobotyzowanej produkcji kosmicznej i wykorzystywania autonomicznych systemów do tego zadania przez pryzmat prawa kosmicznego.

KEY WORDS:

ENG: Space Manufacturing, Space Law, Space Robots, Robot Autonomy, Artificial Intelligence, Space Law

PL: Produkcja kosmiczna, prawo kosmiczne, roboty kosmiczne, autonomia robotów, sztuczna inteligencja, prawo kosmiczne

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