Protection of Patents in Outer Space Could Blockchain Technology Be a Sufficient Solution?

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Abstract

The current and future exploitation of space is driving scientific and technological developments and offers the opportunity for productive international cooperation among nations and space agencies. The continuous involvement of private companies in space developments intensifies the current debate on establishing a legal framework that could provide adequate protection. In fact, the protection of intellectual property rights on discoveries and products linked to these developments will be one of the most important challenges in the exploitation of space. From the beginning, outer space has undeniably been recognized as a unique field that belongs to all humankind and needs to be regulated extraordinarily. In the same vein, space activities require the development of a new generation of patent law, while regulations apply on Earth should serve only as an inspiration. Furthermore, current and emerging Blockchain Technology and its application, named smart contracts, can be employed as a single-window system and provide a transparent and reliable infrastructure for hierarchical storing of patent digital records and accurate enforcement, leaving no space for disputes. Undoubtedly, the interface of patent rights with Blockchain technology and smart contracts in the light of outer space activities creates a suis generis legal framework and forms new legal and ethical challenges that spacefarers should take up.

1. Introduction

For decades, space missions were mainly oriented toward scientific rather than commercial purposes and the space activities were conducted mainly by governments, public institutions, and service providers, creating a monopoly in the industry. In recent years, there has been a rapid increase in the number of States involved in outer space–related activities and in commercial private players and commercial activities that receive the State's authorization for

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exploiting outer space.[1] The example of the International Space Station (hereinafter: ISS) illustrates that, the globalization of space activities characterizes the new space era, emphasizing cooperative initiatives of diverse players from different countries and constituencies.

As science constitutes a condition sine qua non for space exploration and development, there is the need for an effective regulation of the intellectual property rights (hereinafter: IPRs) and specifically patents that attract significant interest. The IP refers to the creations of the human minds and according to World Intellectual Property Organization (hereinafter: WIPO): "a patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem".[2] Patents have a double role; firstly, they provide exclusive rights that protect the inventorship and ownership by supporting the creativity of human mind, and provide investors with a fair return; secondly, publicly disclose, distribute and publish valuable information on the invention that inspire future generations of researchers and inventors.[3]

A series of international agreements govern the patent world. These treaties set the minimum and common standards, rules and measures for patent protection that signed members should adhere to upon creating their national laws and national patent application processes, and, importantly, they create enforcement procedures of patent rights against infringers.[4] Main international treaties are the Paris Convention of 1883 and World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property Rights (hereinafter: TRIPS Agreement). These Treaties do not explicitly refer to patents in outer space but rather ensure that essential principles will be respected, such as national treatment principle (Article 2 PC), the right of priority (Article 4 PC), independence of patents obtained for the same invention (Article 4bis PC), most-favored-nation principle (Article 4 TRIPS Agreement).[5] Thus, different national laws apply and interpret the rules

1 M.K. Davis Cross, Outer space and the idea of the global commons, *International Relations*, 35(3), 384-402, (2021), at 3; D., Aloini, L., Latronico, L., Pellegrini, The impact of digital technologies on business models. Insights from the space industry, *Measuring Business Excellence* 26(1), 64-80, (2022), at 67.

2 WIPO, Intellectual Property and Space Activities Issue paper, (2004), at 2, https://www.wipo.int/export/sites/www/patent-law/en/developments/pdf/ip_space.pdf (accessed 06.09.2023).

3 A-M. Balsano, Intellectual Property Rights and Space Activities, *ESA Bulletin* 79, 34-40, (1994).

4 M. Dineen, For the Betterment of All Mankind: Claiming the Benefits of Outer Space Through Intellectual Property Rights, *Hastings Science & Technology Law Journal*, 13(1), 73-97, (2022), at 85.

5 T. Leepuengtham, *The Protection of Intellectual Property Rights in Outer Space Activities*, Edward Elgar Publishing Limited, UK, 2017, 33-38.

differently. Along with these, Patent Cooperation Treaty (hereinafter: PCT) of 1970 and the WIPO Patent Law Treaty (hereinafter: PLT) of 2000 pertain to the procedure for applying for patents.[6]

In the international space law sector, five main treaties constitute the *corpus juris spatialis* of space law and serve as the binding guidelines for the ratifying states.[7] The Outer Space Treaty (hereinafter: OST) of 1967[8] is the *magna carta* of space law, being the most essential part of legislation and the closest legal instrument to a constitution of outer space.[9] Additional important treaties are the Rescue Agreement of 1968,[10] the Liability Convention of 1972,[11] the Registration Convention of 1975,[12] and the Moon Agreement of 1979.[13] Current international space law treaties do not explicitly consider IPRs in space.[14] The only clear reference to IPRs was made in 1996 by the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) in the Declaration of International Cooperation in the Exploration and Use of the Outer Space for the Benefit and the Interest of All States, Taking into Particular Account the Needs of Developing Countries which writes:

> "States are free to determine all aspects of their participation in international cooperation […] Contractual terms in such cooperative ventures […]should be in full compliance with the legitimate rights and interests of the parties concerned, as, for example, with intellectual property rights".

The need for an international legal regime in the area of patents in outer space will be vital in the following years to facilitate the rapidly increasing cooperative initiatives among the space players and provide incentives for

6 Ibid Leepuengtham; WIPO *supra* note 2, at 5-6.
7 T. Masson-Zwaan & M. Hofmann, *Introduction to Space Law*, Kluwer Law International BV, the Netherlands, 2019, at 3.
8 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 18 U.S.T. 2410 610 U.N.T.S. 205, 61 I.L.M. 386 (1967).
9 F. Obafemi, *Blockchain for Space Governance*. August 2022, https://www.institute.global/insights/tech-and-digitalisation/blockchain-space-governance, (accessed 16.07.2023).
10 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, 19 U.S.T. 7570, 672 U.N.T.S. 119, 7 I.L.M. 149 (1968).
11 Convention on International Liability for Damage Caused by Space Objects, 24 U.S.T. 2389, 961 U.N.T.S. 187 (1972).
12 Convention on Registration of Objects Launched into Outer Space, 28 U.S.T. 695, 1023 U.N.T.S. 15 (1975).
13 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, 363 U.N.T.S. 22, 18 I.L.M. 1434 (1979).
14 Davis Cross *supra* note 1, at 384-402.

more investment in the field. Furthermore, in the constant effort of humankind to explore and understand the unknown, the emerging Blockchain Technology, even in its early steps, appears as the vehicle that solves the concerns due to the lack of a specific IP regime and will disconnect the space market from any governmental authority,[15] at the same time that smart contracts will provide space stakeholders with the ability to automate their cross-organizational contracts using autonomous computer programs.[16]

2. Issues from the Applicability of Patent Law in Outer Space

The application of patent law in outer space is inadequate as multiple and diverse issues have appeared.

Firstly, the national laws related to the acquisition and enforcement of the protection of patents are restricted in the territory of a country, causing a different degree of protection in every country. One example is the lack of protection for "non-commercial experimentation and research" where the definition of each of the terms is different in every national law, causing confusion vis-à-vis the infringement or not of the patented technology in outer space.[17]

Furthermore, even though sovereignty is at the heart of intellectual property rights, in outer space, it is difficult to determine the limits of Jurisdiction due to the lack of territorial borders.[18] States have already agreed on certain principles that enable them to seize Jurisdiction in outer space as it is the general principle that a state retains Jurisdiction and control over the object and any personnel while in outer space or on a celestial body (VIII OST). The example of International Space Station indicates a sufficient solution to that issue. Specifically, the International Governmental Agreement (hereinafter: IGA) of 1998 ISS was the pioneer to state IP protection as an included activity (Article 21 IGA). It introduces the principle of *quasi-territoriality*, meaning that a country's Jurisdiction extends over all the activities, including patents, conducted in its registered module on the ISS.[19] However, IGA constitutes a private agreement and does not establish general terms binding for third parties.[20] Moreover, it might create some interpretative difficulties

15 P. De Filippi, & A. Leiter, Blockchain in Outer Space, *American Journal of International Law (AJIL)* 115, 413-418, (2021), at 416.

16 A. Takyar, *Blockchain 4.0. (n.d.),* https://www.leewayhertz.com/blockchain-4-0/ (accessed 19.08.2023).

17 Balsano *supra* note 3, at 34-40.

18 D.E. Marko, D. A Kinder, Gentler Moon Treaty: A Critical Review of the Current Moon Treaty and a Proposed Alternative, *Journal of Natural Resources & Environmental Law*, 8(2), 293-345, (1993) at 297.

19 Leepuengtham *supra* note 5, at 167-168.

20 M. Weisfeiler, Patent Law in Space, *Boston College Intellectual Property & Technology Forum*, 1-9, (2019), at 3.

and be insufficient as a solution in cases of intergovernmental organizations such as ESA which does not have "national territory" but rather each ESA member state is individually competent.

Moreover, another issue appears regarding cross-border disputes about patent rights since Jurisdiction, applicable law, and judgment enforcement are incredibly costly, time-consuming, and complex due to their dependence on various private international laws. There is no judicial body at the international level assigned to handle these kinds of disputes and unless members agree to go with the Alternative Dispute Resolution procedure, litigation processes should be placed in every country encroached on the law.[21]

Additionally, in some countries, for reasons of national security, the inventor must file an application for patent protection either in the country of residence or in the country where the invention was created. This rule could cause problems in projects related to outer space, involving the cooperation of researchers from different countries.[22]

There is a distinction between patents developed in space and patents brought from Earth to Space. In the former case, complete patent enforcement would require an application for gaining patent rights in every country that can send objects into space; in the latter case, it is unclear whether patents would be protected against international infringement. In any case, it is important that the countries of registration predict to extend their patent protection law to space.[23]

Finally, legal uncertainties due to the lack of specific laws might affect space investments. If the investment refers to one country, it is governed by the laws of the country of registration of the space object. On the other hand, if the investment refers to space-based systems with components in multiple countries, or outer space objects registered in different countries, then a plethora of sources of law apply. Similarly, if the patent is not on file or cannot be easily enforced in the specific country, another entity might take advantage of this lack of law and develop similar patented technology.

The aforementioned issues are indicative of the problem and should be resolved to promote business entities' investments in the field and provide legal certainty in future endeavors.

3. Suis generis Patent Regime for Outer Space

The outer space constitutes a unique, complex entity and does not bear similarities with any place on Earth. When Sputnik conducted its flight, no official complaint for violation of national airspace appeared by other States, thereby establishing an internationally accepted custom that outer space is

21 WIPO *supra* note 2, at 14, 16-17.
22 Id. at 21.
23 Weisfeiler *supra* note 20, at 5-6.

different from territorial airspace. Thus, the international community preserved *ab initio* outer space as a "*province of all mankind*" denouncing it as *res nullius*, declaring it as global commons, and coordinating among themselves to carry out actions that satisfy their shared interests. The territorial features of global commons include but are not limited to the fundamental principles of equal access, non-appropriation, and freedom of exploration and use of outer space described in Articles I and II of the OST. The term "*global commons*" includes areas that are not under the exclusive or partial sovereignty of any individual state or considered to be a part of the international community. In the latter case, all states are granted as "*partial owners*" and are justified to be involved actively in decision-making procedures regarding the right to access, explore, and use space.[24]

With the rapid growth of space industry and the resulting interactions involving governments, the private sector, society, and politics, new challenges have appeared. A shift from national to private initiatives is observed in the newly emerging space business model. In this new environment, international commercial contracts can cause an increasing number of disputes while investors desire to invest in an environment that provides legal certainty regarding their rights and obligations.[25] Adopting quasi-territory should be considered a sufficient temporary solution, but it cannot provide this legal certainty. In every case of international cooperation, clauses specifying patent rights should be agreed upon from scratch.[26] Also, since there are no national territorial boundaries in outer space and each registered space object is subjected to the relevant national patent law, it is effortless for an infringement to appear.

A quick and flexible reaction must be necessary before private space exploration reaches critical mass, gaining independence from national governments and their supervision (Article VI OST). Protection of patents in outer space should be better conducted and reviewed globally at a higher organizational level. In this vein, amendments to the current space treaties could offer a solution, albeit extremely complex, due to the difficult and highly time-consuming decision-making process of gathering States' consensus in UN COPUOS and the new needs of modern space players.[27] Similar difficulties face the approach to amend the IP treaties.

As outer space was recognized as global commons, one efficient solution would be the establishment of a new uniform international suis generis

24 O. De Bittencourt Neto, Outer Space as a global commons and the role of space law, *in*: K-U Schrogl, C. Giannopapa & N. Antoni (Eds.), *A Research Agenda for Space Policy*, UK: Edward Elgar Publishing Limited (2021), at 3, 5.

25 Weisfeiler *supra* note 20, at 4.

26 WIPO *supra* note 2, at 13, 22.

27 C. Steer, Who has the Power? A Critical Perspective on Space Governance and New Entrants to the Space Sector, *Georgia Journal of International and Comparative Law*, 48(3), 751-759, (2020), at 754, 756.

regime for patents in outer space that will define space as a single territory and will require one patent application and jurisdiction rather than a nation-state and sovereign territorial considerations.[28] This application will be universally enforceable and protectable throughout space. In this way, it would guarantee the unified and efficient security of patents in outer space and ensure the interests of the countries and private businesses.[29]

As we are already in the new epoch of Industry 4.0., the disruptive technology of Blockchain can also contribute to the new regime, enhancing the efforts on the creation of robust patent protection regulatory systems and jurisdictional certainty. "*The power of digital is that everyone is working with the same information*" and the features of Blockchain technology and smart contracts offer ground for refining this kind of new legal regime. Therefore, all the Patents would be stored on Blockchain and be enforced by smart contracts.[30]

4. Benefits of Smart Contracts

Smart contracts are parts of software code implemented and stored in the Blockchain. Therefore, understanding the characteristics and features of Blockchain is extremely important because since the Blockchain appeared, it has caused turbulence in the technological ecosystem and the regulatory framework.

4.1. Blockchain Technology as Infrastructure

Blockchain became widely known in 2008 after Satoshi Nakamoto elaborated on the concept of distributed Blockchain in his white paper, which was posted in an encrypted email list entitled "*Bitcoin: A peer-to-peer electronic cash system*". However, fast, the technology unlocked new business models and expanded rapidly to other industries beyond finance. Blockchain, in simple words is "*a distributed digital ledger, based on a P2P network, consisted of a series of blocks that linked using cryptographic signatures and required consensus by all network nodes to store the transactions in blocks*[31]".

28 WIPO *supra* note 2, at 22.

29 Ibid; C. Storr, Space is the Only Way to Go: The Evolution of Extractivist Imaginary of The International Law, *in*: S. Pahuja, & S. Chalmers, (Eds.), *Handbook of International Law and Humanities*, UK: Routledge (2021), at 300-301.

30 ESA, *Speeding up the space industry with digitalised satellites*. November 2018, https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Speeding_up_the_space_industry_with_digitalised_satellites (accessed 05.08.2023).

31 Jones, K.L., Blockchain: Building Consensus and Trust across the Space Sector, *35th Space Symposium*, 1-12, Colorado, United States of America, 2019, at 2; M. Swan, *Blockchain: Blueprint for a New Economy*, USAL O'Reilly, USA (2015), at 1.

4.1.1. Architecture

From the definition, it appears that Blockchain Technology has four main elements that create its robust architecture:[32]

- **The Block** is a unit that stores all the data and connects with other blocks in linear and chronological order, creating a chain. The data in the block are validated by the consensus of all the network peers; from that moment, they are unchangeable. Each block has a unique address, which is also incorporated in the next block and in case the data are altered, it indicates incompatibility with the rest of the blocks of the nodes in the system.
- **The Transaction** is an addition transferred and shared between two peers of the system and added into a new block. Blockchain is the public ledger of all the transactions, growing as new transactions occur.
- **The P2P Network** is a set of actors-nodes interconnected collectively for achieving a single purpose. Each node in the distributed network maintains its own copy of Blockchain and can verify and confirm the transactions.
- **The Consensus** is a method to ensure that all the nodes have the same database within a group, validate entries into a distributed database and obtain secure the database.

4.1.2. Benefits of Blockchain Technology

Regarding protecting patents in outer space, the Blockchain is an excellent ally for facilitating the new IP regime, working as a single-window system of all the relevant data and, providing direct communication and cooperation among different categories of space actors and avoiding any interference from a central authority.[33] This is thanks to its significant characteristics:[34]

- **Decentralized nature**

Any transaction is distributed between all the nodes of the network. There is no intervention of a central authority or administrator, but the nodes are connected directly with each other and are responsible for the data stability using consensus algorithms.

32 M. Pincheira, E. Donini, R. Giaffreda, M. Vecchio, A Blockchain-Based Approach to Enable Remote Sensing Trusted Data, *IEEE Latin American GRSS & ISPRS Remote Sensing Conference (LAGIRS*), 652-657, Santiago, Chile, 2020, at 652-653; H. Ibrahim, M.A. Shouman, N.A. El-Fishawy, A. Ahmed, "Literature Review of Blockchain Technology in Space Industry: Challenges and Applications", *International Conference on Electronic Engineering (ICEEM),* 1-8, Menouf, Egypt, 2021, at 2.

33 Obafemi *supra* note 9.

34 Pincheira *et al supra* note 32, at 652-653; B., Sambana, *Blockchain Approach to Space Industry and Applications*, May 2021, at 1-2. Available at: https://easychair.org/publications/preprint_open/lnbm Accessed 27/03/2023).

- **Transparency**

Any user can see the history of data and participant's actions. The saved-in-block data are immutable and come from any kind of actor, trusted or not.

- **Security**

Cryptographic mechanisms are used in every block since all the data are individually encrypted. At the same time, each block is cryptographically connected with one another since it also includes the address of the previous block in its data.

- **Immutability**

From the moment a block is added to the Blockchain, its data are sealed, and it is impossible to change since any alteration would require huge computational resources and would cause regeneration of the following blocks, indicating a process which is almost unfeasible to achieve.

4.2. Smart Contracts as the Application of Blockchain

Smart contracts are one of the multiple applications of Blockchain Technology and can serve as a valuable tool and facilitate the accomplishment of humankind's goals on exploration and use of outer space, cooperation, and development. Smart contracts can be simple or complex, depending on their code. Every patent rule and relative steps can be adjusted to code, facilitating the detection and confirming compliance with them.
The Smart Contracts are

> "set of protocols running automatically on the top of Blockchain network. They are usually implemented with programs on a computer network, or in other forms of digital electronics, are designed to self-execute when the predetermined conditions are met and write any resulting change into the distributed ledger."[35]

4.2.1. Features of Smart Contracts

Smart contracts deploy all the characteristics of Blockchain technology and include two more specific features connected directly to their nature and applicability:[36]

- **Autonomous electronic nature**

Smart contracts exist only in electronic form. They are based on cryptographic digital signatures in order to ensure the data will not be altered

35 Id. Pincheira at 653; Smart Contracts Alliance, *Smart Contracts: Is the Law Ready?*. 2018, at 10. https://lowellmilkeninstitute.law.ucla.edu/wp-content/uploads/2018/08/Smart-Contracts-Whitepaper.pdf (accessed 25.08.2023).

36 Ibid Smart Contracts Alliance; Swan *supra* note 31, at 16; A., Savelyev, Contract law 2.0: 'Smart' contracts as the beginning of the end of classic contract law, *Information & Communications Technology Law* 26(2), 116-134, (2017), at 123-124, 126.

and have autonomy, namely, no intermediary is needed from the moment they start running in the system.

- **Self-enforceability**

Smart contracts' enforceability is based on a series of clauses in the form of *if-then* orders inserted in the specific blockchain system. The predetermined computer code verifies that all requirements are followed and transfers assets while creating entries in the Blockchain ledger about these transfers.

4.2.2. Importance of Oracles

A smart contract can conduct calculations, store information, and automatically send funds to other accounts. However, smart contracts are incapable of enforcement outside of their technological framework and thus, human element appears still vital for the system's efficient function. Specifically, a smart contract framework depends on the existence of oracles that act as objective, verifiable intermediates between smart contracts and imported relevant and trusted information and on the action of authority in dispute cases. Apart from humans, these Oracles as external information sources can also be websites or sensors.[37]

5. Evaluation of the use of Smart Contracts

The autonomy and decentralized nature of Blockchain and smart contracts serve as indisputable evidence for patent rights and concurrently cause a scattering of regulation going beyond the knowledge of the well-known processes and creating new challenges for the regulatory authorities.

Smart contracts and Blockchain as an infrastructure for space applications and a new space regime for patents in outer space will be subject to international law and relevant governance principles in outer space, such as the peaceful exploration and use of outer space, cooperation and mutual assistance, international responsibility, and international liability.[38] At the same time, though, it is necessary to examine whether the benefits from the characteristics of the technology supersede the withdrawal from authority over the deployed system, in order to restructure the legal system to meet these technological changes.[39]

5.1. Jurisdiction and Sovereignty

The distributed nature of Blockchain breaks the chains with a single jurisdiction while the immutability and transparency of the ledger offer self-

37 De Filippi *supra* note 15, at 416.

38 A-S. Martin & S. Freeland, The Advent of Artificial Intelligence in Space Activities: New Legal Challenges, *Space Policy, 55*, 5-6, (2021), at 5-6.

39 Obafemi *supra* note 9.

sovereignty independence to the system.[40] It introduces the concept of agnostic Jurisdiction and appears as the most efficient and equitable model for administering and securing patent rights in censorship and regulation.[41]
There is a concern that the decentralized nature of Blockchain creates the same problems that patent rights face in outer space regarding Jurisdiction. It is incredibly challenging to identify the governing law since, hypothetically, if there is no Jurisdiction clause, then every transaction could fall under the Jurisdiction of the location of each node of the network, increasing the number of applicable regimes.[42]
There is no international consensus over the property and sovereignty relations in space. Companies seek new means to ensure legal protection for their assets and investments. Even though the legal validity of smart contracts is based on the laws of national jurisdictions, Blockchain Technology allows a new regime of traditional property and contract law. In this new regime, the enforceability is not based on the law of countries but is the result of autonomous technological pre-described rules inserted in a specific Blockchain.[43]

5.2. Legal Implications of the Use of Smart Contracts

Smart Contract is not just a piece of software but incorporates technical and legal parts. Thus, a legal smart contract is "a smart contract that articulates and is capable of self-executing, on a legally enforceable basis, the terms of an agreement between two or more parties."[44]

Functional Implications

Smart contracts are analogous to traditional agreements since the parties agree on a peculiar set of rules and the potential consequences in case one of the parties breaches its obligations.[45] At the same time, they differ in that they do not require trust between the parties. After all, the code defines and executes the contract.[46]
In a hypothetical scenario of infringement of patent rights, the determination of the national law governing the interpretation of the contract and the applicable Jurisdiction, in case of disputes, takes much time during the negotiation procedures. However, using smart contracts for the same regime

40 K. Ziolkowska, Distributing authority–state sovereignty in the age of Blockchain, *International Review of Law, Computers & Technology*, 35(2) (2021), at 120,122.
41 Swan *supra* note 31, at 30-31.
42 J. McKinlay, Pithouse, D. Sanders, J. McGonagle, J. *Blockchain: background, challenges and legal issues*. February 2018, https://www.dlapiper.com/en-us/insights/publications/2017/06/blockchain-background-challenges-legal-issues (accessed 26.08.2023).
43 Storr *supra* note 29, at 300-301.
44 Smart Contracts Alliance *supra* note 35, at 12.
45 B.R. Israel, Space Governance 3.0, *Georgia Journal of International & Comparative Law* 48, 715-730, (2020), at 723.
46 Swan *supra* note 31, at 16.

category could help overcome the barrier of transactional friction and simplify regime formation.[47]

A smart legal contract may incorporate the terms of a new patent regime regarding space, either translating the human language into code or embedded directly in a scripting language, contributing to the reduced vagueness that traditional terms would cause. The most important problem with smart contracts concerns modifications and amendments since the computer code can only accept accurate conditional instruction in the form of *if-then*. For instance, it is impossible to include a term whose definition will be interpreted differently according to each phase, performance, or execution. In this restriction, one potential solution could be the adoption of multisignature prerequisites that would enable to lock, unlock, or amend the smart contract. For example, a smart contract with a future legally binding effect could incorporate a provision that checks whether there is a successful smart contract countersigned by the parties to the original contracts.[48]

Non-Human Presence Implications

Smart Contracts do not provide complete independence by third parties since, as we examine above, the Oracles play a vital role in the information inserted in the system. Therefore, there is an operational risk related to the role of Oracles since incorrect or false information submitted in smart contracts can create errors in the computer program, which are extremely difficult to fix due to the solid interconnections that characterize the distributed ledger. In such cases, a third human party is essential for checking the code's validity and, if necessary, reinserting the third-party Blockchain.[49]

It is also challenging to depict in code abstract legal concepts as the *force majeure*, the *good judgment*, or *good faith*. In that case, smart contracts should rely on a national legal system or human interpretation unless compliance with an agreement was objectively determined.[50] Smart contracts receive inputs and give a specific output based on the information received. On the other side, human logic follows a different path. The middle stages and parameters will be unpredictable even if there is specific information and knowledge of the desired output.[51]

47 Israel *supra* note 45, at 722-723.

48 Smart Contracts Alliance *supra* note 35, at 27-28.

49 L. Efimova, O. Sizemova, A. Chirkov, Smart contracts: between freedom and strict legal regulation, *Information & Communication Technology Law*, 30(3), 333-353, (2021), at 352; H. Vertadier, *The Application of the Blockchain Technology to the Space Industry*. January 2019, at 29, https://www.researchgate.net/publication/341887995_The_Application_of_the_Blockchain_Technology_to_the_Space_Industry (accessed 09.09.2023).

50 Israel *supra* note 45, at 723.

51 T. Kirsch, Legal Issues for Blockchain in an Environment Most Unkind, *Blockchain Law,* 2, 1-13, (2020), at 9.

5.3. Ethical Implications of the Use of Smart Contracts

The unique characteristics of Blockchain and smart contracts cause emerging risks, including legal and ethical elements mainly related to equitable access to outer space, privacy, and the legal power of the code.

Access to Global Commons Implications

Using Smart Contracts Could Be Beneficial For establishing an equitable relationship among all space stakeholders. Commercial companies' priorities focus on the potential profit from selling the technology to other companies or national governments. In order to do this, they have to ensure that their patent rights are accurately protected. Undoubtedly, thriving and active participation in space activities requires understanding the latest technological capabilities and making investments in capacity-building. These might create difficulties for developing countries.[52]

Privacy Implications

Blockchain's immutable audit trail provides the ultimate level of transparency and resilience, but at the same time, it might generate privacy challenges concerning private data and specifically the right to be forgotten.[53]
The patent digital records stored in a public Blockchain could violate privacy laws. For this category of Blockchain, the registration and access to the ledger for new entries are public and no one is responsible for the availability of security of the network. This contradicts privacy laws that demand the presence of a party to protect individual data.[54]

Power of Code implications

Smart contracts, due to their autonomy and self-enforceability, allow the code to act as law, eliminating the uncertainty of diverse interpretations of rules, decreasing the risks of errors, and guaranteeing the smooth application of the law.[55] In traditional human regimes, the parties have the discretion to breach or comply with the agreed rules, contrary to code-based contracts that, rules are self-enforceable. This lack of the parties' freedom in a future code-based international regime might create a negative tone.[56] The challenge lies in accurately depicting the legal regulations concerning parties' intent in code language and confronting the smart contracts as a technological tool in constant development, meaning that they might soon be obsolete due to programming advances.

52 A. Aldrin, Technology Control Regimes and The Globalization of Space Industry, *Space Policy*, 14(2), 115-122, (1998), at 120.
53 McKinlay *supra* note 42.
54 J. Salmon & G. Myers, *"Blockchain and Associated Legal Issues for Emerging Markets"*, World Bank Publications-Reports 31202, The World Bank Group, 1-8, (2019), at 323.
55 Vertadier, *supra* note 31, at 26.
56 Swan *supra* note 31, at 17.

6. Conclusions

The peaceful and prosperous regulation of global commons is a highly challenging mission requiring exceptional coordination skills and, most importantly, the satisfaction of the competing interests of stakeholders in these commons. Specifically, future space regulation in the field of intellectual property and specifically in patents in outer space should seek new regulatory mechanisms that establish an adequate legal framework for the efficient protection from improper use and abuse and the benefit of all the creators and all States. Patent law issues in outer space will be preferable to regulate and approach them as international global problems for the benefit of all humankind with international legal and governance solutions. In that way, it is likely to avoid situations where individual States or companies would be given excessive authority to act and interpret according to their interest in a global area.

In that effort, Blockchain technology and its application, the smart contracts, are not another Information Technology but constitute new technological initiatives and have contributed to decreasing cost, time, risk, and complexity across a range of business, operational, and security applications and require thorough examination and understanding.[57] Thus, conducting interdisciplinary research between traditional law and smart contracts is the first step for lawmakers to be capable of effectively regulating them.[58]

Blockchain and smart contracts will not modify the core of the international space law principles, but they will be transformational regarding the applications and activities that apply in space.[59] Due to their precision and enforceability, smart contracts could assist the establishment of a legal framework that would be a great ally in the efforts of an international legal set of patent rules for outer space. However, at present, Blockchain and smart contracts are only operational inside their technological ecosystem and become ineffective when one activity interacts outside the Blockchain, and the presence of third-party trusted entities is necessary. The system's lack of absolute autonomy makes the new technologies only a tool for boosting the traditional regulatory mechanisms without entirely replacing them.

57 Jones, K.L., Blockchain In The Space Sector, Aerospace, 1-17, (March 2020), at 1; T., Olbrechts, *Welcome to Space 4.0*. May 2022, https://www.digitalengineering247.com/article/welcome-to-space-4.0/digital-thread (accessed 25.08.2023).

58 S. Voshmgir, *Token Economy: How the Web3 reinvents the internet*, Germany: Blockchain Hub Berlin - Token Kitchen, Germany (2020), at 174.

59 P. J. Blount & J. De Rossi., Blockchain and Smart Contracts in Space Operations, *in:* L.S. Smith, I. Baumann S-G. Wintermuth, (Eds), *Routledge Handbook of Commercial Space Law*, 405-417, UK: Routledge (2023), at 416.

Blockchain Technology, Artificial Intelligence (hereinafter: AI), and Internet of Things are known as the "*holy trinity of disruptive technology*".[60] Already from the early applications of AI, one can see that the technological civilization is expected to undergo a comprehensive transformation. Now, the involvement of the human factor is taking a "*human-on-the-loop*"[61] form since the smart contract has more autonomy but is supervised by a human control regime. Combining smart contracts with AI can solve the technological and legal obstacles and lead to a new space era.

In conclusion, the Blockchain and smart contracts can contribute to a more democratic, accessible and participatory governance, enhancing public-private or private-private cooperation. "Space exploration has already been a great unifier. We seem able to cooperate between nations in space in a way we can only envy on Earth."[62]

60 A. Wainscott-Sargent, *Blockchain: The Next Big Disruptor in Space*. August 2017, https://interactive.satellitetoday.com/blockchain-the-next-big-disruptor-in-space/ (accessed 16.08.2023).

61 Martin & Freeland *supra* note 38, at 3.

62 M. Wall, *Stephen Hawking Wants to Ride Virgin Galactic's New Passenger Spaceship*. 2016, https://www.space.com/31993-stephen-hawking-virgin-galactic-spaceshiptwo-unity.html, (accessed 26.07.2023).