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Perspectives of Blockchain for the Modern Space Activity

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Summary: This paper is based on the study dedicated to the legal nature of the DLT (distributed ledger technologies), and in particular to Blockchain as its most popular example, the basic elements and models of the technology, the main spheres of its application in the framework of space activity in order to guarantee realization of rights and compliance with obligations of public and private space actors in the process of conducting the outer space activities, as well as legislative innovations to regulate the utilization of Blockchain in different countries, international standards, practices and promising legal mechanisms. The authors consider usage of different types of Blockchain ledgers (public ledger with authorized access and with/without special validator) to implement different tasks in the process of space activity regulation, such as guaranteeing fulfillment of terms and conditions of foreign economic agreements on the basis of smart contracts concluded between business entities and for maintaining the state register of space objects. The research proposes several scenarios that are acceptable both in terms of technical characteristics of Blochchain and legal requirements under which a number of central authorities can exercise their powers to regulate space activities using DLT. The most precise attention is focused on considering the compliance of the space authorization requirements, ensuring the registration of space objects and the implementation of foreign trade agreements within the space sector of the economy.

Keywords: space, space objects, blockchain, legislative

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1. Introduction

One of the most widespread technologies for managing data, including remote sensing data for environmental protection, is Blockchain. Despite the fact that this technology is about 20 years old, a lot of studies have been devoted to explaining of their nature and different spheres of their realisation, among which we have analysed the works of O. Dubinina, P. Kravchenko, O. Kud, M. Kucheriavenko, Y. Strokova, A. Bagmet, M. Rozhkova, B. Scriabin, E. Smychko, V. Liashenko, O. Vyshnevsky, Karen J. Jones, Mohamed Torky, Tarek Gaber, Aboul Ella Hassanien, Rohit Mital, Jack de La Beaujardiere, Rohan Mital, Marge Cole, Charles Norton, Silvia Petruzzino, Manav Gupta, Swapnil Anil Surdi, Jonathan Emmanuel, Nadya Reingand, John Popper, Efraim Turban, Jon Outland, David King, Jae Kyu Lee, Ting-Peng Liang, Deborrah C. Turban, etc.

The Blockchain ideology aims at avoiding the influence of the regulator, which stems from the desire for political freedom and autonomy, as well as skepticism about state power, that are the basis of the libertarian movement ("cradle" of Blockchain). From the other prospective, the space activity is a type of economic activity that should be controlled in order to guarantee protection of state secrets, preservation of intellectual property related to innovative developments at the national level and prevention of its illegal use or possession, security for all participants (space actors), protection of the environment, as well as minimization of the creation of space debris, state compliance with the international obligations on non-proliferation of weapons of mass destruction, insurance of state liability and third-party liability of the entities intending to conduct space activity, and registration of space objects. In this paper, the different dimensions of combining the Blockchain and space activity are revealed, and the authors are convinced that Blockchain technology can potentially meet the requirements of modern space activity.

2. The nature of Blockchain technology

There are many interpretations of Blockchain technology and they all reflect different aspects of it. Since Blockchain is a derivative technology of DLT, the most common definition of Blockchain is a distributed database in which every transaction and its details are recorded simultaneously by all users (i.e. all nodes) without a central database or administrator (peer-to-peer transmission)[1]. At the

[1] JONES, K.J. Blockchain in the Space Sector. Center for Space Policy and Strategy. Game Changer, March 2020. 17 p. [online] Available at: https://csps.aerospace.org/sites/default/files/2021-08

same time, records are made in a unit of account, which encrypts the physical indicator of the resource that is actually the subject of the transaction: a unit of value of property or service, the right of access to the system, access to information or other right or obligation (token).

At the same time, Blockchain is also defined as a technology that provides management of an indefinite number of transactions carried out by network users directly on the basis of consensus and storage of transactions in cryptographically protected units of information – "Blocks"[2], each of which is united by a hash value using a special algorithm based on the data of previous blocks. This process constitutes the so-called Blockchain transaction protocol, which is checked by users and, if it is properly followed, approved by consensus, after which the transaction data is updated in all blocks. The transaction history is available to anyone with software access to the registry. A specific person does not have the technical ability to make changes to an already validated block of information, as any changes must be consensually agreed between participants through peer-to-peer data transfer. To interact in the system, each user has a pair of keys: a private key and a public key. The private key corresponds to the concept of an electronic digital signature, i.e. it is unique for each user and is not available to others, while the public key is used to encrypt messages (transactions) and is available to all network participants.

Each of these definitions reflects the specific characteristics of Blockchain technology, such as decentralization, immutability of records, transparency, so it is primarily a technology for organizing data according to a specific protocol for consensus decision-making on transactions. There are different models of Blockchain technologies, including public, private or consortium[3]; public without permission, public with permission, private without permission, and private with permission[4]; open participation/open recording, open participation/recording with permission, closed participation/recording with permission[5],

/Jones_Blockchain_03052020.pdf.

2 TORKY, M., GABER, T., HASSANIEN, A. E. Blockchain in Space Industry – Challenges and Solutions. Blockchain in Space Industry – Challenges and Solutions. *egyptsceince.net*, 27 p. [online] Available at: https://www.researchgate.net/publication/339616244_Blockchain_in_Space_Industry_Challenges_and_Solutions.

3 BEAUJARDIERE, J. D., MITAL, R., & MITAL, R. Blockchain Application Within A Multi-Sensor Satellite Architecture. *IGARSS 2019–2019 IEEE International Geoscience and Remote Sensing Symposium*, 2018, pp. 5293–5296.

4 PETRUZZINO, S. Blockchain and Smart-Contracts: a New Challenges for International Commercial Arbitration. *Czech Yearbook of Arbitration. Arbitration and International Treaties, Customs and Standards.* 2020, vol. 10, pp. 161–179.

5 JONES, K.J. Blockchain in the Space Sector. Center for Space Policy and Strategy. Game Changer, March 2020. 17 p. [online] Available at: https://csps.aerospace.org/sites/default/files/2021-08/Jones_Blockchain_03052020.pdf

public decentralized networks, public networks with decentralized management, private networks controlled by the government[6]. This taxonomy is mainly based on 4 characteristics:

– publicity – any user (node) has access to the network with the right to read data;
– privacy – only users with a specific identity, members of the same community or company have access to the network with the right to read data, which ensures the confidentiality of information in the network and the network itself has a higher degree of trust;
– non-permissible – any user can validate, i.e. check transactions for compliance with the protocol rules and confirm them, as well as insertion data into distributed records;
– permissible – only certain users can validate, i.e. check transactions for compliance with the protocol rules and confirm them, as well as insertion data into distributed records.

Blockchain as a data organization technology is combined with a variety of software codes that define the logic of network transactions, ensuring their full automation, namely smart contracts. On the one hand, a smart contract can be considered as a transaction, namely, it contains the following elements: 1) parties/signatories – counterparties that have certain agreements with each other (an electronic digital signature or a multi-signature may be used to certify the will of the parties, if there are a large number of counterparties); 2) subject matter – assets that must be located within the smart contract implementation system or have an appropriate connection with it (for example, the smart contract must provide for a system for digitally informing the bank where the assets are located about the execution by the parties of agreements that allow the bank to carry out the relevant transaction); 3) conditions – a list of algorithms, upon fulfilment of which the parties will consider the contract to be executed. On the other hand, as Silvia Petruzzino points out, a smart contract can be as smart as it was coded by human. This means that the code can only contain terms and conditions that do not allow for discretion and differences in interpretation[7]. From this point of view, smart contracts are understood as a way of executing traditional legal contracts, for example, the most common of which is the transfer of funds between counterparties.

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[6] KUD, O., KUCHERIAVENKO, M., SMYCHOK, E. *Digital assets and their legal regulation in the light of the development of blockchain technology: a monograph*. Kharkiv: Pravo, 2019. 216 p. (original in Ukrainian)

[7] PETRUZZINO, S. Blockchain and Smart-Contracts: a New Challenges for International Commercial Arbitration. *Czech Yearbook of Arbitration. Arbitration and International Treaties, Customs and Standards*. 2020, vol. 10, pp. 161–179.

Another feature of smart contracts is that they are localized only within the network. Communication with the outside world is ensured by special services that send and verify data from external electronic sources outside the Blockchain network, transmitting data to smart contracts, thus enabling their execution (oracles). Currently, there are three main types of oracles: for proving data on certain events (in particular, data on temperature, pressure, humidity in a certain room), for forecasting (in particular, price fluctuations on stock exchanges), and for recording private data (in particular, personal data or data on ownership)[8].

3. Blockchain applications in the space industry

Understanding the nature of Blockchain lets us pass to the next step of research. Based on the analysis of scientific sources, it was identified the following main areas of application of Blockchain technology in the space industry:

1) *Financing space start-ups and asset creation through tokenization, that can take place on the basis of an ICO (Initial Coin Offering) or STO (Security Token Offering)*. Such types of projects offer to purchase tokens issued through smart contracts in an existing chain that uses its own tokens and is valid only for that chain. This process is actually the tokenization of a particular product or service for the duration of its use[9]. In essence, an ICO is a process of generating and distributing tokens between buyers who invest in a particular product and/or service that is then delivered by a company, using tokens generated by the company for a specific project on an individual basis. Investors participating in an ICO have the opportunity to receive so-called "utility tokens", which gives them access to the product or service immediately after the tokens are issued. The financial incentive in this case is the prospect that once the product/service is launched, the price of the tokens will start to rise, thus creating a profit for the investor. Such a scheme is not unique to the space industry and can be applied to the real estate, logistics and agricultural sectors, as crowdfunding mechanisms are widely used in the modern world. However, given the fact that the space business is an area where investments are returned no earlier than five years after the initial investment, space startups have an alternative to waiting for a venture capitalist

[8] KARPILOVSKIY, D. B. *Bitcoin, blockchain and how to make money on cryptocurrencies* / Moscow: AST, 2018. 256 p. (original in russian).

[9] PODYACHEV, S. Business logic should come first, and only then – tokens as a tool. *Mind.ua*. [online] Available at: https://mind.ua/publications/20214717-stanislavpodyachev-spochatku-mae-jti-biznes-logika-a-vzhepotim-tokeni-yak-instrument?fbclid=IwAR39NvI0j66si0oQGErEmPcdknABShZeuPrKwnqvbVZEUU0T3lzyiGWFa4. (original in Ukrainian).

to come along. The tokens can be distributed to an indefinite number of investors who will invest small amounts of money that will be affordable to them. This makes investing more affordable and faster. For example, SpaceChain, a startup, launched bitcoin sales on the Qtum platform in early 2018 to ensure the construction of a grouping of satellites that would provide services to everyone based on Blockchain technology. However, along with interesting projects, there were also completely unrealistic ones whose founders conducted an aggressive marketing campaign similar to the activities of pyramid schemes. It is not surprising that the value of 90% of such tokens is now close to zero[10]. Unlike an ICO, an STO involves raising funds through tokenized securities, which are a cryptocurrency-based asset that derives its value from any other asset it represents, such as real estate or gold, but most importantly, they can represent shares, other securities or their alternatives. Thus, STOs can be compared, in particular, to uncertificated negotiable securities, and accordingly, their placement is regulated by the Securities and Stock Market Commissions and the relevant legislation, which, in our opinion, makes them more reliable for investors. At the same time, it should be noted that, as there are currently several approaches to defining the nature of tokens and their respective grouping, some countries establish the jurisdiction of currency and financial regulators over placements even in the form of ICOs. Thus, despite the absence of unambiguous criteria for distinguishing between different types of tokens that provide investment, the legal and organizational basis for ensuring their safe circulation is already being formed.

2) *Tokenization of space assets for other than investment purposes mean the recognition of rights and obligations of both space objects and sections of orbits, celestial bodies or their parts in tokens as objects of rights and obligations*. The above may help to monitor, using smart contracts on the Blockchain platform, the changes that occur with the relevant tokens, and therefore with the rights to the relevant physical objects, as well as to change data not only on their legal features, such as ownership, but also on technical parameters, such as changes in location, the presence of an obstacle that determines the relevant location and the time of such changes, which may help to form schemes for the movement of certain objects and predict their changes in the future, etc. With the help of an appropriate system, it is possible to make significant progress in solving the problem of space debris by recording information on real-time updates to the Blockchain network.

[10] SpaceChain White Paper. [online] Available at: https://spacechain.com/wp-content/uploads/2020/03/
whitepaper-200320.pdf

3) *Tokenization of requirements for remote sensing, navigation, and geolocation data* could be analyzed by software on satellites and ground stations, resulting in more efficient operation of the latter and faster delivery of the necessary quality data to the user. In addition, unalterable, time-fixed records of the creation of new value-added remote sensing data by each supplier would allow them to effectively track the data they are to purchase or dispose of on the network, as well as to prove their right to the created product. Consumers of the relevant services could benefit from a catalog of relevant records to help them navigate the wide range of remote sensing data services on offer.
4) *Conducting public procurement in the space industry and ensuring strong audit control for all stakeholders and over all parties to procurement – both customers and contractors*. Transparency of procurement can be ensured on the basis of a public open-source Blockchain and control over participants can be ensured by the state regulator through authorization of transactions. In addition, efficient procurement processes with faster automated payments through smart contracts are privided.
5) *Ensure cybersecurity of space assets through supply chain management*. Space technology is currently multinational, thousands of contractors from different countries can be involved in the supply of both hardware and software elements for one space object. In the event of a cyberattack, this makes it quite difficult to trace and identify the entity that laid the so-called backdoor (an element that allows unauthorized access to equipment, disabling it or stealing data). Blockchain technology, with its inherent property of immutability of records within specific time periods, can more likely ensure that an attacker will not be able to change or delete the relevant records. In other words, having a complete supply chain of elements to each space object contributes to the visibility, traceability and accountability of products, thereby increasing the overall transparency of the process. At the same time, even the open-source code of the Blockchain network protocol can be updated with the consent of the participants, who may not be aware of all the risks of such an update, including the risks of installing a backdoor, but the fact of the update and its time will be recorded, which will help to identify it. Thus, in the context of strengthening the cybersecurity of space activities, Blockchain could contribute in 2 ways: 1) protecting the economic interests of private space entities associated with the loss of intellectual property or other material losses; 2) compliance with international obligations of States regarding liability for national space activities caused, for example, by the failure of a space object as a result of a cyberattack, and tort relations between States in a broader context, in particular, the consequences of the use of cyberweapons as one of the manifestations of the use of force and the development of

proportionate means of counteraction. Currently, there is debating the issue of a legal obligation to provide clear and convincing evidence of a cyberattack allegation against a particular country to ensure cross-checking and corroboration of such an allegation[11]. And although the policy of States is still more inclined to arbitrary presentation of such evidence, technically, accounting for deliveries on the Blockchain as part of the full cycle of space projects has the potential to both protect against cyberattacks and collect evidence of their commission and identify the perpetrators.

6) *Managing information about the full cycle of mission execution*. A Blockchain network can be created for almost every mission, with the following participants: a service customer, a satellite service provider, satellite manufacturers, their suppliers and subcontractors, a launch service provider (operator), a mission control center, a satellite operations center, regulatory authorities, an insurance company, and a consortium that acts as a mission database for third parties. Each participant receives its own node and a personal access key to it, which stores copies of the network activity register and smart contracts. Channels are created between participants. In this case, the satellite manufacturer can also create separate channels among its suppliers and subcontractors. After that, the assets that will be displayed in the network and become part of the subsystem are identified. Smart contracts are created for their smooth circulation. For example, when a contractor detects a failure during product testing, the smart contract deflects further steps until the causes of the failure are identified and eliminated. Subcontractors purchase parts from suppliers, and then design, manufacture, and test satellites; based on the work performed, the relevant acts are generated in digital form. The satellite manufacturer assembles and delivers the satellites to the launch service provider, and the launch service provider installs the satellites on the launch vehicle and transfers it to the mission control center. At the same time, the smart contract could contain provisions for checking weather conditions before the launch. In the event of adverse weather conditions, the launch will be postponed, which will also be reflected in the smart contract. Once all the satellites are placed in the planned orbit, the satellite service provider takes over the functions of monitoring their activities. Additional channels in the network could be created for regulatory authorities that can intervene at any stage of the mission and for insurance companies that have access to certain data. The launch data is available through the interfaces of application programs for research institutions, where all forms of interaction with the

[11] EICHENSEHR, K. E. The Law and Politics of Cyberattack Attribution. *U.C.L.A. Law Review.* 2020, vol. 67, pp. 520– 598.

data, including its upload and download, are tracked. All of the above actions are recorded in the form of transactions in the immutable registry database, which allows for further audit by any authorized interested network participants. Technically, the use of such a system will automate the process of informing all counterparties about the next stage of work or service provision within a particular mission and will facilitate the proper and reliable storage of data on each of these stages, the completion of which will be confirmed by the relevant transaction. In addition, the time and costs of administrative services, including the licensing procedure, will be reduced due to the fact that the regulatory authority will be a direct participant in the network. This application opens up wide opportunities for States to transfer such institutions as insurance, technical requirements for launch trajectory, flight parameters and even data on the object itself for its registration in accordance with the requirements of international space law, etc. At the same time, given the diversity of space technology and its requirements, as well as the different requirements of the relevant services market, the state regulatory system could prescribe the minimum requirements for the smart contract code to be met, which would not exclude the possibility of business entities fulfilling additional conditions in accordance with agreements with their counterparties.

7) *Secure satellite communications*. The creation of virtual security zones of different levels involves the use of satellites for data processing and storage as Blockchain nodes with a unique identification code assigned to each of them. In this case, the loss of a satellite could be recorded in the blocks of all nodes as an identification code that can no longer be used, while the addition of a new satellite to the constellation is verified by requesting the identification codes of all satellites in the constellation, and the satellites of the constellation verify the code of the new satellite. Similarly, establishing communication with a satellite from another constellation should be accompanied by mutual verification of their identification numbers. Thus, the use of applications developed on the Blockchain platform creates conditions for secure communication both among themselves and between large groups of satellites[12].

[12] TORKY, M., GABER, T., HASSANIEN, A. E. Blockchain in Space Industry – Challenges and Solutions. Blockchain in Space Industry – Challenges and Solutions. *egyptsceince.net*, 27 p. [online] Available at: https://www.researchgate.net/publication/339616244_Blockchain_in_Space_Industry_Challenges_and_Solutions.

4. Legal framework for the use of Blockchain

This seems quite natural, since the rules governing relations in the field of Blockchain technology are difficult to limit to any one jurisdiction, because although nodes may be located within different States, the records they enter into the blocks do not cross borders but occur simultaneously in all nodes. Thus, both the rules of private international law and legally non-binding customs and doctrinal recommendations of authoritative institutions, as well as technical standards, play a major role in regulating the relevant issues. At the same time, some unified rules have recently begun to be developed not only within the state, but also at the regional level.

On the international level the International Association for Trusted Blockchain Applications (INATBA) in cooperation with the International Organization for Standardization within the framework of Technical Committee 307 developed the technical regulations ISO/TR 23455:2019 (Blockchain and distributed ledger technologies – Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems)[13], ISO/TR 23244: 2020 (Blockchain and distributed ledger technologies – Privacy and personally identifiable information protection considerations)[14], and ISO/AWI TS 23259 (Blockchain and distributed ledger technologies – Legally binding smart contracts)[15]. In addition, the ISO TC68 Financial Services Technical Committee created the multidisciplinary international standard ISO 20022, which describes the general requirements for all messaging platforms and applications (including those used within the Blockchain network)[16]. The International Telecommunication Union also has elaborated the platform to analyse the requirements for standardisation of applications and services based on distributed database technology[17]. International private entities or research institutions of the IT sector also made an

[13] ISO/TR 23455:2019 (Blockchain and distributed ledger technologies – Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems). [online] Available at: https://www.iso.org/standard/75624.html.

[14] ISO/TR 23244:2020 (Blockchain and distributed ledger technologies – Privacy and personally identifiable information protection considerations). [online] Available at: https://www.iso.org/standard/75061.html.

[15] ISO/AWI TS 23259 (Blockchain and distributed ledger technologies – Legally binding smart contracts). [online] Available at: https://www.iso.org/standard/75095.html.

[16] ISO 20022 (Universal financial industry message scheme). [online] Available at: https://www.iso20022.org/

[17] ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT). [online] Available at: https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/ITU-Asia-Pacific-CoE-Training-on-Distributed-Ledger-Technologies-(Blockchain)-Ecosystem-and-Decentralization/ITU%20DLT.pdf

input, for example, the Enterprise Etherium Alliance[18] and the World Wide Web Consortium[19] also elaborated Blockchain standards.

On 10 April 2018, 30 European countries signed the Declaration on the Establishment of the International Blockchain Partnership, which aims to establish the European Blockchain Services Infrastructure (EBSI) to ensure the provision of digital services in compliance with cybersecurity and privacy requirements. European states agreed to jointly explore the issue of finding areas of business where the use of Blockchain will be most effective[20]. As a result, on 03.10.2018, the European Parliament adopted a Resolution on distributed ledger technology and blockchain: building trust without limits. This resolution defines the concept of distributed ledger technology, smart contracts, the specifics of their use in certain areas of business (energy, financial, healthcare, education, supply, intellectual property rights protection, transport), as well as requirements to promote the development of this technology, such as standardization, scalability, consistency of distributed ledgers and their application, as well as legal support for their operation[21]. In the same year, 2018, the European Blockchain Observatory and Forum was established, a platform to engage and assist business entities to integrate blockchain technology in the most favorable way, for which purpose, under its auspices, research on legal and technical aspects of this issue is carried out, implementation of findings and training.

At the EU level, the European Space Agency, in a study of the possibilities of using distributed ledger technology for Earth observation, stated that there is not yet a wide range of Blockchain users, as there is no infrastructure for implementing Blockchain in this area. At the same time, it outlined the directions of implementation of this technology in the field of the European remote sensing system to manage metadata in cloud environments, track the supply of equipment for the ground and space segments, improve the circulation of digital licenses through smart contracts, and more secure ways of using copyright [22].

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[18] Why Standards are "What's Next" in the Web 3.0 Blockchain Revolution. [online] Available at: https://entethalliance.org/why-standards-are-whats-next-inthe-web-3-0-blockchain-revolution/

[19] Blockchain Community Group (BlockchainCG at W3C TPAC2017). [online] Available at: https://www.w3.org/community/blockchain/

[20] Cooperation on a European Blockchain Partnership: Declaration, 2018. [online]. Available at: https://www.scribd.com/document/398159396/2018DeclarationonEuropeanPartnershiponBlockchainpdf-pdf.

[21] European Parliament resolution of 3 October 2018 on distributed ledger technologies and blockchains: building trust with disintermediation (2017/2772(RSP)). [online] Available at: https://www.europarl.europa.eu/doceo/document/TA-8-2018-0373_EN.html

[22] Blockchain and Earth Observation. ESA White paper, April 2019. 28 p. P. 20–23. [online] Available at: https://eo4society.esa.int/wp-content/uploads/2019/04/Blockchain-and-Earth-Observation_White-Paper-April-2019.pdf

United States of America is also actively developing legislation in the field of Blockchain technology in the following areas: certification of transactions with digital signatures (keys), regulation of the circulation of money and financial instruments, simplification of taxation, as well as determination of the system of administration of the use of digital assets in various fields. At the same time, the regulation is mainly focused on the use of Blockchain in the financial sector, but there is a prospect of its expansion through legal regulation of issues related to the use of tokens not as electronic funds or securities, but as an electronic expression of property rights[23]. Non-profit organisation "Institute of Electrical and Electronics Engineers" of the United States within the framework of the IEEE P2418 series of standards has developed the IEEE DLT/blockchain standards, focused on the creation of common frameworks and architectures for distributed databases, their technical interoperability, technology building blocks and vertical industry standards[24].

At the same time, a similar orientation of legal regulation is reflected in the countries of the Eastern region. As part of the implementation of the Dubai Blockchain Strategy[25], the Securities and Commodities Authority in February 2020 introduced the Regulatory Framework for Digital Securities and Virtual Assets Offerings under the Financial Services and Markets Regulations[26]. The Regulatory Framework recognizes tokens generated for ICOs as securities, and the Authority is currently working with the Abu Dhabi Securities Exchange and Dubai Financial Market to develop specialized trading platforms for ICOs. In addition, the Regulatory Framework states that ICOs can be implemented in a variety of forms, but all of them use DLT. An investor transfers assets in virtual form to the issuer of an ICO in exchange for a personal digital equivalent – a coin or token. However, tokens can be not only a digital representation of a financial asset, but also an identification record, voting rights, and a means of accessing a network operating on the DLT. The regulatory framework allows the creation of a register of shares, bonds and other securities on DLT platforms. In such cases, the issuance of tokens is regulated similarly to the issuance of shares, bonds, units in a collective investment fund[27].

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[23] Blockchain law guide. [online] Available at: https://blockchainlawguide.com/blockchain/

[24] IEEE DLT/blockchain standards. [online] Available at: https://blockchain.ieee.org/standards

[25] Dubai Blockchain Strategy. [online] Available at: https://www.smartdubai.ae/initiatives/blockchain

[26] Guidance – Regulation of Digital Security Offerings and Virtual Assets under the Financial Services and Markets Regulations. [online] Available at: https:// en.adgm.thomsonreuters.com /sites/default/files/net_file_store/Guidance-Digital_Securities_Offerings_and_Virtual_Assets_VER04.240220.pdf

[27] Abu Dhabi Global Market's new financial regulatory framework. [online]. Available at: https://www.shearman.com/~/media/Files/NewsInsights/Publications/2016/02/Abu-Dhabi-Global-Market-Financial-Services-Regulations-and-Rules-FIAFR-022416.pdf

Republic of South Africa has not formed special legislation to regulate the circulation of crypto assets, but crypto assets are not prohibited. The prospect of introducing regulation for distributed ledger networks, including Blockchain, as in most countries, is considered exclusively in the context of the functioning of the cryptocurrency market based on this technology. This is in particular due to the fact that there is an objective need to regulate the circulation of "crypto tokens", "crypto assets", "digital tokens", the legislative definition of which is currently being worked on by the Intergovernmental Financial Technology Working Group (IFWG) formed in 2019 and the Cryptocurrency Asset Regulation Working Group (CARWG) established in 2018, which includes representatives of the National Treasury, the South African Reserve Bank (SARB), the Financial Services Commission (FSCA), the South African Revenue Service (SARS), and the Financial Intelligence Centre (FIC). However, in 2019, the Intergovernmental Working Group on Financial Technology issued a Consultation Report containing proposals for a policy on the regulation of crypto assets[28], which emphasizes the need for a legislative definition of crypto assets and the distributed ledgers on which they operate, including Blockchain, noting that the use of Blockchain technology helps to prevent fraud in the field of financial technology.

The above mentioned gives the possibility to conclude that both Blockchain technology, integrating into business sectors, qualitatively transforms them, and the new relations, developed on this basis, require new comprehensive legal regulation, which should cover such legal institutions:

– Property law: the category of digital rights can be defined as a property right to a digital asset, i.e. the right to ownership of information.
– Contract law: a smart contract, electronic digital signature, including cryptographic keys should be recognized as valid.
– Protection of the rights of consumers.
– Protection of personal data, that can be open for everyone in the Blockchain network.
– Securities and financial regulation, including in accordance with anti-money laundering rules.
– Taxation and administration (licensing, granting permits for activities related to the use of Blockchain technology, including cloud services).

Thus, in order to ensure high-quality legal support for the use of Blockchain technology in various business sectors, the adoption of the so-called framework law defining the relevant terminology and key issues related to Blockchain is

[28] Crypto Assets Working Group. Consultation paper on policy proposals for crypto assets. [online] Available at: https://cdn.crowdfundinsider.com/wp-content/uploads/2019/01/South-Africa-CAR-WG-Consultation-paper-on-crypto-assets_final.pdf.22. Int

only the first minimum necessary step, which should be accompanied by further transformation.

For instance, the most recent attempt to introduce regulation in the field of digital assets in Ukraine was the draft law No. 3637 "On Virtual Assets" submitted to the Verkhovna Rada of Ukraine on 11 June 2020. This draft law does not contain definitions that would reflect the meaning of the concepts of "distributed ledger", "smart contract", "oracle". However, there is a definition of "virtual asset", which mean not only cryptocurrency assets, but may well include electronic cash, which is a digital reflection of the currency issued by the relevant state regulator[29].

However, there is a provision (Art. 10(2)) that does not consider custody or administration of virtual assets to be activities that do not allow the custodian or administrator to dispose of virtual assets independently or to control the keys of virtual assets of third parties. Such a provision contradicts the very nature of a private virtual key, which is the same non-transferable and confidential information as an electronic signature available in Ukrainian law. In addition, this rule contradicts Article 944 of the Civil Code of Ukraine, according to which a custodian has no right to use the thing transferred to him for storage or transfer it for use to another person without the consent of the principal[30].

According to Article 6(2) of the draft law, the conditions of acquisition, transfer and scope of rights to virtual assets may be expressed in the form of algorithms and functions of the virtual asset circulation system within which it was created. Such provision may be considered a hint at the algorithms used in smart contracts, but it would be more correct to indicate that the transaction itself may be expressed by a set of algorithms, and provide for its fixation with an electronic signature or virtual key. The draft law refers to the expression by an algorithm of the conditions of acquisition, transfer and scope of rights to virtual assets[31]. However, in a network of distributed data registries, the concept of an algorithm is much broader, since any activity in the network is carried out according to a certain algorithm (a set of instructions describing the procedure for the performer to achieve the result of solving a problem in a finite number of actions), including potentially illegal ones.

At the same time, the current legislation of Ukraine already has certain legal mechanisms that may indicate the first stages of readiness of the national digital

[29] On virtual assets: Draft Law of Ukraine. [online] Available at: http://w1.c1.rada.gov.ua/pls/zweb2/webproc4_1?pf3511=69110 (original in Ukrainian)

[30] Civil Code of Ukraine. [online] Available at: https://zakon.rada.gov.ua/laws/show/435-15#Text (original in Ukrainian)

[31] On virtual assets: Draft Law of Ukraine. [online] Available at: http://w1.c1.rada.gov.ua/pls/zweb2/webproc4_1?pf3511=69110 (original in Ukrainian)

infrastructure for the implementation of Blockchain technology. In particular, the Law of Ukraine "On Electronic Commerce" recognizes the equality of legal force of electronic transactions and transactions concluded in another form provided for by law, the essential terms of an electronic contract, the seller's obligation to require from the buyer only such information without which the conclusion and fulfilment of obligations under an electronic contract is impossible, to take measures to protect personal data, and to ensure full compliance of the subject matter of an electronic contract agreed by the parties with the quantitative and qualitative characteristics, etc[32]. At the same time, the legal model enshrined in this law contradicts such inherent features of Blockchain technology as the distribution of transaction records across nodes, the temporal determinism of transaction records, and the transmission of information in cryptographic form. Thus, only some provisions of the relevant law can be applied to transactions within the Blockchain network by analogy.

5. Regulation of space activities using blockchain technologies

Blockchain is a suitable platform to create an individual network for a certain range of entities within a specific type of legal relationships between them. Just as separate distributed ledgers were once created for cryptocurrencies (including Bitcoin or Ethereum), a separate network can be organized to implement authorization mechanisms and control space activities. Technologically, when organizing a network, it is possible to provide for creating several parallel channels, where the conditions of interaction between contractors will be set out and smart contracts will be implemented between them, taking into consideration that such channels do not necessarily have to be visible to other network members. However, it is manageable to provide an option under which all network members will have the right to request the information that is necessary to fulfil the terms of transactions where they directly act as counterparties, from the channels where they do not directly partake, if such a request is duly justified. Such information can be received via oracles.

Thus, taking into account the requirements of paragraph 4 of the "Procedure for issuance (refusal to issue, cancellation) of permits for certain types of space activities", approved by the Resolution of the Cabinet of Ministers № 197

[32] On electronic commerce: The Law of Ukraine. [online] Available at: https://zakon.rada.gov.ua/laws/show/675-19#Text (original in Ukrainian)

on February 26, 2020[33], The Blockchain network could become a platform for a permitting system regulating space activities, which would include, inter alia, records on the following conditions for a particular type of space activity:

1) identification data of the network participants;
2) information on the payload to be launched into orbit and the country that is the ultimate beneficiary of such launch;
3) terms of the transfer of ownership in orbit: identification data of the initial and final owner, date and legal grounds of such transfer;
4) standards according to which space object is certified;
5) insurance contract or other method of financial security of delictual obligations;
6) confirmation of compliance of space activities with the requirements of environmental legislation.

In our opinion and according to the "Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects" adopted by the Resolution of the General Assembly No. 62/101 on January 10, 2008, it would also be appropriate to add the obligation to register a space object to the relevant requirements, i.e. to provide the UN Secretary-General with additional information on the space object, namely:

– the geostationary orbit location, where appropriate;
– any change of status in operations (inter alia, when a space object is no longer functional);
– the approximate date of decay or re-entry, if States are capable of verifying that information;
– the date and physical conditions of moving a space object to a disposal orbit;
– web links to official information on space objects[34].

Moreover, taking into account the absence of a final decision on the issue of import substitution of supplies from the Aggressor State to Ukraine, as well as real threat of its presence in the space sector of the Ukrainian economy, we are convinced of the need to display specific space project documentation in the Blockchain network that will confirm the following information about the foreign space actor:

– the foreign counterparty of the Ukrainian space actor is not an entity that is registered or whose founders are registered and / or located in off-shore zones

[33] Procedure for issuance (refusal to issue, cancellation) of permits for certain types of space activities approved by the Resolution of the Cabinet of Ministers of Ukraine № 197 on February 26, 2020. [online] Available at: https://zakon.rada.gov.ua/laws/show/197-2020-%D0%BF#Text

[34] Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects adopted by the Resolution of the General Assembly No. 62/101 on January 10, 2008. [online]. Available at: https://www.unoosa.org/pdf/gares/ARES_62_101E.pdf

or in the territory of the states included by the Financial Action Task Force (FATF) in the list of states that do not cooperate in the field of combating money laundering;
– is not subjected to sanctions in accordance with the legislation of Ukraine, which provides for the restriction or prohibition of trade and / or financial transactions;
– is not subjected to sanctions in accordance with resolutions of the UN Security Council, other international organizations, decisions of the Council of the European Union, other intergovernmental associations and foreign states, which provide for the restriction or prohibition of trade and / or financial transactions;
– does not originate from a country recognized as the occupier and / or the aggressor state toward Ukraine in accordance with the provisions of law;
– has not been declared bankrupt, no bankruptcy proceedings have been instituted against him;
– is not in the process of termination of the status of a legal entity.

The relevant network can be organized as a closed /private network in order to ensure protecting against the disclosure of the above mentioned information relating the space actors, checking transactions for their compliance with the rules of the protocol and confirming them, enabling the export control authorities to enter data into distributed registers directly or in accordance with a specified protocol.

The main technical difficulty of implementing the Blockchain technology in government agencies and state registries is that any state registry must be located at a specifically defined server that remains under state control. Blockchain system provides distributed data storage on multiple servers, so that database management on Blockchain occurs autonomously and independently from any central supervision.

Unfortunately, nowadays there is no technical infrastructure in Ukraine that could enable implementation of control over the distributed network of servers through the capacities of one specific regulatory authority. However, there is an option of applying Blockchain for the purpose of space activity regulation when distributed servers are located in all central executive authorities that perform certain regulatory functions over space actors in accordance with Ukrainian legislation in force.

After presenting the general vision of using the Blockchain technology to regulate space activities, we would like to focus on one of the most problematic aspects, namely ensuring the registration of space objects. The urgency of this problem is confirmed by the analysis of the data received from the UN Online Index of Objects Launched into Outer Space, which currently contains more

than 700,000 unregistered space objects, more than half of which remain in orbit[35]. It is common practice that the space object can be registered either by all launching states, or none of them bears responsibility for it and the object remains unregistered. Quite often the payload owner tries to place all the responsibility for registration on the owner of the launch vehicle, arguing that the significant role in bringing the space object into orbit is performed by the launch vehicle. In fact, an application for the payload registration is almost always submitted by the payload owner, not by the launch vehicle owner or the launch service provider. Thus, the most widely known practices of space objects registration, where the foreign entity is present, are currently of a purely formal nature and do not create any conditions for state control over the compliance of space actors with their obligation to register space objects launched on their behalf and remaining under their control.

The model of space objects registration on the Blockchain platform could be implemented under the following legal preconditions:

1) legislatively promulgated requirement to determine the party responsible for the space object registration in contract on the provision of space launch services, the terms of which must be subsequently retransmitted into smart contract;
2) relevant legislative provision in the national law of all the counterparties or a reference to the acceptable jurisdiction (the legal order of one of the States of registration of counterparties) by the provisions of international law.

The implementation of the first precondition can be quite a challenging task, as it contradicts the key principle of contract law – the principle of "the autonomous will of the parties", i.e. the freedom of contractors to determine the terms of the contract concluded between them. Freedom of contract also follows from the provisions of the UN General Assembly Resolution "Guidelines for Consumer Protection" № 39/2484 adopted on April 9, 1985 according to which consumers should be protected from such contractual abuses as one-sided standard contracts, exclusion of essential rights in contracts and unconscionable conditions of credit by sellers[36].

On the other side, contract law involves the concept of the essential terms of the contract, which must be fulfilled as a mandatory condition ensuring that the deal between the parties goes through. Therefore, contracts on the provision of space launch services could contain a condition on the designation of the state of

[35] WRIGHT NELSON, J.. Lost in Space? Gaps in the International Space Object Registration Regime. *EJIL: Talk!*, November 19, 2018. [online] Available at: https://www.ejiltalk.org/lost-in-space-gaps-in-the-international-space-object-registration-regime/.

[36] UN General Assembly Resolution „Guidelines for Consumer Protection" № 39/2484 adopted on April 9, 1985. [online]. Available at: https://zakon.rada.gov.ua/laws/show/995_903#Text

registry by virtue of the obligations undertaken by States under the Convention on Registration of Objects Launched Into Outer Space. As US practice shows, the obligation to register a space object can be assigned to a particular state at the stage of concluding the contract on the provision of space launch services. To this end, both a special form of a contract or specific contractual provision can be provided. For example, a launch services agreement that SpaceX usually concludes with its customers (in particular, such an agreement was concluded in the context of the Falcon-9 launch) contains the following provision: «Compliance with Government Requirements. Customer shall be responsible for registration of the Satellite Batch and every Satellite, and SpaceX shall be responsible for registration of the Launch Vehicles, pursuant to the Convention on Registration of Objects Launched Into Outer Space, done January 14, 1975»[37].

In addition, standard contract, being used by the parties of the launch services agreement, allows to define a clause according to which the parties agree upon the state of registry of the space object, that can be further displayed in smart contract. Standard and model contracts are the form of state regulation of contractual relations in the spheres of economical activities, that are used to facilitate the conclusion of commercial contracts and determine the desirable model of contractual obligations from the standpoint of the State. According to article 179 of the Commercial Code of Ukraine, the Cabinet of Ministers of Ukraine and executive authorities designated by the Cabinet due to the provisions of legislation in force can recommend to business entities approximate conditions of commercial contracts (model contracts), as well as approve standard contracts in cases specified by law. Standard contracts may include two types of terms: 1) terms from which the parties can not deviate; 2) terms that can be specified or determined by the parties at their discretion[38] . However, the legislation of Ukraine does not contain the grounds on which either state-owned or private space actors of Ukraine are obliged to apply standard contract when concluding commercial agreements with foreign business entities.

Currently article 13 of the Law of Ukraine "On space activity" states[39]: If a space facility has been designed jointly with corporate entities of other countries or with international organizations, the question of its registration shall be decided in accordance with the international agreements (contracts) concluded. The mentioned provision demonstrates the recognition of necessity to implement

[37] SpaceX. Space Exploration Technologies Corp. Launch Services Agreement. [online] Available at: https://www.sec.gov/Archives/edgar/data/1361983/000119312513112208/d468141dex102.htm

[38] The Commercial code of Ukraine. [online] Available at: https://zakon.rada.gov.ua/laws/show/502/96-%D0%B2%D1%80#Text

[39] The Law of Ukraine "On space activity". [online] Available at: https://zakon.rada.gov.ua/laws/show/502/96-%D0%B2%D1%80#Text

this term, but it can hardly be considered peremptory norm in the context of Article 638 of the Civil Code of Ukraine[40], after fulfillment of which the contract is deemed to be concluded. Moreover, according to Part 2 of Article 32 of the Law "On Private International Law"[41], in case the applicable law has not been chosen, the law that has the closest connection with the contract shall apply to it, in particular the law of the contractor`s state (Part 1 of Article 44). Therefore, the relevant provision may be integrated at the discretion of the counterparties. Given the development of Blockchain application for the registration of space objects in different states, it will be possible to include the mechanism of registration via Blockchain in a standard contract, while defining the conflict-of-laws rule due to which space objects shall be registered in the Blockchain network under the legislation of one of the counterparties.

After the successful implementation of Blockchain technology in the digital infrastructure of Ukraine, the next step should be the incorporation of relevant provisions in legislative acts regulating the foreign economic activity of space actors. Such the provisions should be aimed at engaging executive authorities (such as the state Space Agency of Ukraine and other authorities involved in the granting permits for certain types of space activities) as an equal member into the network that will be created for each specific project, where Ukrainian and foreign entities are going to act as the counterparties.

Since Article 11-1 of the Law of Ukraine "On space activity" sets the requirement for state-owned space entities of Ukraine regarding mandatory notification of negotiations and concluded agreements (contracts), registration of concluded agreements (contracts) for foreign commercial activity, it makes sense to monitor the registration of space objects at the stage of conducting negotiations and concluding agreements between the counterparties, while tracking the subject of negotiations and agreements. Thus, we are convinced of the expediency of reflecting this mechanism in Art. 11–1 of the Law of Ukraine "On space activity" with the subsequent adoption of resolution of the Cabinet of Ministers on the approval of a standard form of foreign economic agreements (standard contract) in the field of space activities, that will also establish an obligation to define the state of registry of the space object[42].

Similarly, smart contracts between Ukrainian and foreign private entities may stipulate that the registration of launch vehicle and payload should be carried out

[40] The Civil Code of Ukraine. [online] Available at: https://zakon.rada.gov.ua/laws/show/435-15#Text

[41] The Law of Ukraine "On private international law". [online] Available at: https://zakon.rada.gov.ua/laws/show/2709-15#Text

[42] The Law of Ukraine "On space activity". [online] Available at: https://zakon.rada.gov.ua/laws/show/502/96-%D0%B2%D1%80#Text

by their owners in accordance with the laws of the countries where the owners are registered as space entities. This condition forces private entities to submit an application form containing necessary information to the executive authorities in their states and conduct the coordination procedures with them in case the state of counterparty has not implemented Blockchain regulation at the legislative level yet and the registration authority does not have the technical capability to join the network. If the Blockchain technology is properly regulated in the states of all counterparties, then all registration authorities can become members of such a network. When the terms of the transaction are completed, information from the network (including orbit parameters, information on ownership, insurance of the space object) is transferred to the state register of space objects by means of oracles, that accelerates the registration process and eliminates the need for further issuance of the registration certificate for business entity, as the certificate can be sent to the entity in cryptographic form.

In light of above mentioned, we propose the following types of Blockchain networks to meet different demands:

1) *for the purpose of the fulfilment of foreign commercial agreements (contracts) on the basis of smart contracts concluded between business entities:* a public network with authorized access, the information in which is transparent to all members (although in case of need to protect trade secrets or other sensitive data, a private network with restricted access can be defined), but only the authorized member (any participant of legal relations for foreign commercial activity) approved by all the network members is allowed to enter records. Thus the authorization procedure may be reflected in programming code, instead of its performing by authorized members of the network in a manual mode;
2) *or the purpose of maintaining the State register of space objects:* a public network with authorized access, where the State Space Agency of Ukraine is empowered to be a validator.

However, not all the state registers can be organized as the public ones. For example, export control authorities may play a role of validators in the relevant Blockchain network to guarantee the transparency and controllability of management of military or dual-use goods supply, provided that such the practice is acceptable in different space-faring states. It is worth mentioning, that records on the international transfer of dual-use or military goods in the Blockchain network would be monitored even more closely, given that they are permanent and fixed within a certain time-bound framework, if all states participating in the respective regimes (Missile Technology Control Regime, Wessenaar Arrangement, etc.) could be validators of the corresponding system, closed for an unauthorized access.

6. Conclusions

As a result of the conducted research the following scientific positions and recommendations are formed:

Through the use of Blockchain Network it is possible to ensure transparent monitoring of space actors` compliance with the permitting procedures (issuance of permits), while smart contracts implemented on its basis can enable automatic execution of the procedures mentioned above and acceleration of information exchange between all participants of space activity.

The application of Blockchain technology in the regulation of space activities can be ensured by placing network servers in all central executive authorities, that in accordance with the current legislation of Ukraine perform certain regulatory functions in relation of space activities, namely the Ministry of Strategic Industries of Ukraine, which ensures the formation and implementation of state policy in the field of space activities[43], the State Space Agency of Ukraine, which implements state policy in the field of space activities[44], the Ministry of Defence of Ukraine, which conducts space activities in the field of defense and national security, in particular the Department of Information Technologies of the Ministry of Defence of Ukraine, authorized to conduct, in accordance with the law, space activities in the field of defense and national security of Ukraine (in the field of cybersecurity)[45], the State Export Control Service of Ukraine, which implements state policy in the field of state control over international transfers of military and dual-use goods[46], the Ministry of Environmental Protection and Natural Resources of Ukraine (in case space activities are included in the types of planned activities in the definition of the Law of Ukraine "On Environmental Impact Assessment")[47], as well as other bodies, which will directly or indirectly be related to each specific mission. Such the approach will promote: 1) exercising the powers of public authorities in relation to space activities; 2) practical application of the DLT-technology in

[43] Regulations on the Ministry of Strategic Industries of Ukraine approved by the Resolution of the Cabinet of Ministers of Ukraine №819 on September 7, 2020. [online] Available at: https://zakon.rada.gov.ua/laws/show/819-2020-%D0%BF#Text

[44] Regulations on the State Space Agency of Ukraine approved by the Resolution of the Cabinet of Ministers of Ukraine №281 on May 14, 2015. [online] Available at: https://zakon.rada.gov.ua/laws/show/281-2015-%D0%BF#Text

[45] The Law of Ukraine "On space activity". URL: https://zakon.rada.gov.ua/laws/show/502/96-%D0%B2%D1%80#Text

[46] Regulations on the State Export Control Service of Ukraine approved by the Resolution of the Cabinet of Ministers of Ukraine №159 on March 31, 2015. [online] Available at: https://zakon.rada.gov.ua/laws/show/159-2015-%D0%BF#Text

[47] The Law of Ukraine "On Environmental Impact Assessment". [online] Available at: https://zakon.rada.gov.ua/laws/show/2059-19#Text

space activities; 3) implementation of the full cycle space projects; 4) speeding up and facilitating the relevant permitting and registration procedures for space actors (entities intending to conduct space activity).

The entity responsible for registration of space object can be determined in two ways: 1) by including this condition as essential into contracts for the provision of launch services; 2) by proposing to conclude a standard contract in this area. In both cases it is recommended to set out the relevant condition in smart contracts generated in the unified network for a certain space mission. In this context, given the multinational nature of such the network, a vital role will belong to the legal disclaimer concerning an appropriate condition in the national legislation of the counterparties or reference to the relevant jurisdiction (legal order of state where one of the counterparties is registered) according to the provisions of international law.

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