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POLSKA AKADEMIA NAUK ODDZIAŁ W GDAŃSKU
KOMISJA NAUK KOSMICZNYCH

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Dr Magdalena Konopacka
Dr Paweł Chyc

Per mare ad astra
space technology, governance and law

Vol. II

GDAŃSK 2021

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Nasze życie jest takim, jakim uczyniły je nasze myśli.
Marek Aureliusz

Z OKAZJI OSIEMDZIESIĄTYCH URODZIN

prof. Zdzisław Brodecki

W latach 1958–1963 studiował prawo na Uniwersytecie Jagiellońskim w Krakowie i Uniwersytecie Mikołaja Kopernika w Toruniu. Od 1963 roku był pracownikiem UMK w Toruniu, a od 1966 roku Wyższej Szkoły Ekonomicznej w Sopocie (wchłoniętej w 1970 roku przez Uniwersytet Gdański). Stopień doktora nauk prawnych uzyskał w roku 1968 na Wydziale Prawa UMK w Toruniu. Habilitacja w 1978 roku na Wydziale Prawa i Administracji Uniwersytetu Warszawskiego. Od 1994 roku jest profesorem tytularnym.

W roku akademickim 1972/73 był stypendystą British Council i odbył studia post-doctorate w University College of London, a w roku akademickim 1985/86 przebywał jako visiting professor w University College Cardiff. Przez wiele lat pracował jako ekspert w International Maritime Organization (IMO) w Londynie. Obecnie jest ekspertem Commiteé Economique et Social Européen (CESE) w Brukseli. Przez dwie kadencje pełnił funkcje przewodniczącego Polskiego Stowarzyszenia Prawa Morskiego i Polskiej Sekcji Międzynarodowego Stowarzyszenia Prawa Ubezpieczeniowego. W latach 1978–1996 był kierowni-

kiem Katedry Prawa Morskiego, a od roku 1996 był kierownikiem Katedry Prawa Europejskiego i Komparatystyki Prawniczej na Uniwersytecie Gdańskim. Jest promotorem ponad tysiąca prac magisterskich i ponad dwudziestu rozpraw doktorskich. Uczestniczył w charakterze recenzenta w kilku przewodach habilitacyjnych i kilkunastu przewodach doktorskich. Otrzymał wiele nagród ministra za osiągnięcia w dziedzinie badań naukowych. Za stworzenie teorii zintegrowanego porządku prawnego Kapituła nagrody im. Jana Heweliusza przyznała profesorowi Z. Brodeckiemu nagrodę w 2009 roku w dziedzinie nauk humanistycznych.

Obecnie jest zatrudniony stanowisku profesora zwyczajnego w Wyższej Szkole Administracji i Biznesu im. Eugeniusza Kwiatkowskiego w Gdyni. W tym okresie wspólnie z profesorem Edmundem Wittbrodtem zainicjował powołanie w gdańskim oddziale PAN Komisji Nauk Kosmicznych, która po roku funkcjonowania doprowadziła do przekształcenia Polskiego Klastra Morskiego w Bałtycki Klaster Morski i Kosmiczny (Baltic Sea & Space Cluster) w Gdyni. Dzięki tym inicjatywom pracownicy i studenci WSAiB w Gdyni biorą czynny udział w wielu konferencjach międzynarodowych organizowanych przez Komisję Nauk Kosmicznych wspólnie z Bałtyckim Klastrem Morskim i Kosmicznym oraz publikują swoje referaty w periodyku „Per mare ad astra". Profesor Zdzisław Brodecki posiada nieoceniony wkład w rozwój nauk kosmicznych i inspiruje kolejne pokolenia do materializowania swoich pasji naukowych.

Z okazji 80 urodzin prof. Zdzisława Brodeckiego:
Wdzięczni wychowankowie i współpracownicy.

Georgii Ilich Sibirtsev
University of Business and Administration in Gdynia

PHILOSOPHICAL AND LEGAL PERCEPTION OF COSMOS: HISTORY AND PERSPECTIVES

Abstract: This article is considering the origins of philosophical representation of Cosmos as The Universe State and briefly tracing its totemistic preconditions, stemming from the primitive mythopoetic thinking. The author analyses the perception of cosmos in different philosophical schools, trying to demonstrate the connection between totemistic mythological attitude, stoic school, Hugo Grotius' legal theory, Konstantin Tsiolkovski's conception of „monism of the universe" and modern legal regulation of the outer space. The author considers that the international agreements on outer space could be examined as a continuation of the classical philosophical concepts of ancient Greek schools and tries to predict further development of the legal regulation in this sphere.

Key words: outer space law, definition of „Cosmos", the stoic ethics, totemism, K. Tsiolkovsky, Moon Treaty, Outer Space Treaty, liability for outer space malicious exploration.

INTRODUCTION: UNIVERSE AS SOCIAL REFLECTION

Mankind tries to explain the descent and organization of the universe from the very first days of the civilization. This field of cognitive uncertainty seems to be one of the strongest irritants in human history. First, magic, religion and philosophy were the instruments for understanding of the world around us, only later did science appear among those cognitive systems. Talking about each and every state throughout civilization we are considering first of all particular perceptions of the universe, methods of understanding the world, but despite that, a great amount of these attitudes has much in common. Before we start to analyze the state of the art on the related topic, it is necessary to dwell upon the history of the „Cosmic" philosophy, because many modern legal concepts find their roots in

ancient traditions of the perception of the world around us. Caused by fear of *terra incognita* (lat. unknown territory) and lack of scientific knowledge, our predecessors' consciousness struggled with the inscrutable and unpredictable world of nature with all possible methods. According to Jerzy Kierul[1], the essential reaction that is triggered in a person by a reflection on the universe is what can be called „metaphysical vertigo"[2].

„Cosmos" is a term which has a very long history and, as I already had the boldness to state in the title of the article, perception thereof has changed significantly, from the highest law to a fragile value which needs to be protected, using lawful measures. First definitions appeared in ancient Greece, but first attempts of the universe understanding were made many centuries before the Greek civilization. With the emergence of the first states in the Middle East, totemistic ideas about nature acquired a certain social objectification. Thus, „the Mesopotamian civilization interpreted the universe as a state. […] This interpretation was based on the primitive democracy"[3].

The Mesopotamian space state concept included the entire existing world, „everything that could be thought of as really existing: people, animals, inanimate objects, natural phenomena, as well as concepts such as justice, righteousness, etc"[4]. Roughly the same idea of kinship, if not identification of the universe with the state, headed by the Pharaoh, is seen in ancient Egyptian culture; hence the sacred figure of the king in ancient Asian monarchies, which most often was the personification of the whole world and the Sun, as well as a specific year. Unfortunately, there are not enough relevant written sources on the Minoan civilization. The available expanded texts of the linear „B" scripts are, as a rule, bureaucratic and economic in nature[5]. But it seems that similar views about the identification of the cosmos and the state could have taken place in the states of the Aegean region at that time. After all, we should not forget about the Middle Eastern genesis of the Minoan culture and the constant ideological influence on the inhabitants of Mycenaean cities by the people of the Eastern Mediterranean[6].

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1 J. Kierul, *Ład świata.Od kosmosu Arystotelesa do Wszechświata Wielkiego Wybuchu*, pub. PIW, Warszawa 2007, p. 9–12.

2 https://www.ancient-origins.net/unexplained-phenomena/ancient-spaceflight-0010517(dostęp: 07.08.2021).

3 O.M. Freidenberg, *Миф и литература древности* [Mif i literatura drevnosti], Moscow, pub. Science, p.30.

4 O.M. Freidenberg, *Миф и литература древности* [Mif i literatura drevnosti], Moscow, pub. Science, p.30.

5 F. Shcherbakov, *Метафора космоса – как полиса в стоическом учении и его этико-коммуникативные следствия* [Metafora kosmosa–kak–polisa v stoichceskom uchenii i ego etiko-kommunikativnye sledstviia], Philosophy, p.10.

6 F. Shcherbakov, *Метафора космоса – как полиса в стоическом учении и его этико-коммуникативные следствия* [Metafora kosmosa–kak–polisa v stoichceskom uchenii i ego etiko-kommunikativnye sledstviia], Philosophy, p.10.

However, with the beginning of the archaic era, with the process of colonization and the growth and appearance of new Greek poleis, a tendency immediately appeared of „rhythmisation" of social life[7], associated with cosmic-natural universal laws. In this, again, one can see a trace of primitive ideas about the whole collective of people and the entire nature, and about a certain „first body" that gave life to everything that exists, for the benefit of which it is necessary to work[8]. The result of this attitude to nature was the emergence of Athenian democracy. It assumed that every free citizen is as good and full of *ἀρεταί* (greek „virtue") as any other, so everyone could become a participant in making important social decisions.

The magic and mythology as a cognitive system created on the one hand a primitive picture of the world, but on the another hand, this picture has a complete and comprehensive character. Sensations and fears of the subject were reflected in the created system, the main rule for the world order being the will of god (for mythology) and will of human being (for magical practices). For many societies, the universe was filled with unbroken laws (for instance the Romanian concept of „*Pax deorum*"[9] or the Stoic concept of „Cosmopolis") which should not be changed and, what is more important, can not be measured. These concepts developed from the prehistoric totemistic traditions of connection of external world with internal actions of social members, describing the world as a mechanism balancing between the order and chaos.

O.M. Freidenberg names two features of primeval thinking – the understanding of plurality through singularity and the identification of the human collective with visible nature. „The cognized world, and the person who comprehends, it are merged. Human shades are not recognized; everything human is represented by the external world. The outside world is presented in the form of people"[10]. This leads to such well-known phenomenon as anthropomorphization of society, animals, the Universe and nature as a whole, implying the notion (but not yet a philosophical idea) of the total kinship of living beings, of their connectedness, in which the human world, fauna and flora have not yet been divided into the hierarchically arranged niches of being recognizable to us. „All natural phenomena – organic, inorganic and abstract – had the same essence[11]. Black is not opposed to white, but the entire universe is a certain spectrum in which one color

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7 F.O. Shelling, *Философия искусства* [Filosofiia iskusstva], Moscow, pub. Thought, 1999, p. 37.

8 F.O. Shelling, *Философия искусства* [Filosofiia iskusstva], Moscow, pub. Thought, 1999, p. 38.

9 *Pax*, though usually translated into English as peace, „was a compact, bargain or agreement. In religious usage, the harmony or accord between the divine and human was the *pax deorum* or *pax divom* ("the peace of the gods" or "divine peace").

10 O.M. Freidenberg, *Миф и литература древности* [Mif i literatura drevnosti], Moscow, Science, 1978, p. 14.

11 F. Shcherbakov, *Метафора космоса – как полиса в стоическом учении и его этико-коммуникативные следствия* [Metafora kosmosa–kak polisa v stoichceskom uchenii i ego etiko-kommunikativnye sledstviia], Philosophy, p.13.

passes into another without a clear border between them; in which, in fact, one color can turn into another under the influence of certain conditions".

Stoic metaphorisation of the Cosmos – as – Polis, was, in a sense, a justified and even inevitable phenomenon. Striving to reconstruct the world outlook of people of the archaic era, to comprehend its rituals, myths and those facts of material culture that have come down to our time, one can see that the world was perceived by ancient man as undivided, imaginative, anti-causal, but at the same time sensual and specific. In spite of the fact that those first steps in understanding the surrounding world were mostly ineffective, sometimes our ancestors managed to achieve a surprisingly thorough insight. For example, the theory of atomism (connected usually with the name of Democritus) is one of the classic examples of the effectiveness of the Greek philosophers' observation method. Ancient Greeks are credited with many early advancements in the cosmic science, which later influenced the western civilization. Aristarchus of Samos proposed an essentially heliocentric cosmology millennia before Copernicus[12].

Socrates was quite accurate on his perception of the cosmos. He stated that by reason of feebleness and sluggishness, we are unable to attain to the upper surface of the air; if anyone should come to the top of the air or should get wings and fly up, he could lift his head above it and see, as fishes lift their heads out of the water and see the things in our world, so he would see things in that upper world; and, if his nature were strong enough to bear the sight, he would recognize the real heaven, the real light and the real Earth[13].

The way cosmos was perceived, was at some point a special kind of social authentication directed from one to itself and from another point to the external world. One of the latest forms of such „mutual" perception of the universe (more elaborate and developed) can be found in works of K. Tsiolkovsky, G. Leibniz, or C. Jung. One of the latest concepts of the totemistic world perception could be named „Panpsychism". This explanation of the concept could be found in works of K. Tsiolkovsky, who presents an idealistic view of the universal animations of nature. Historical forms of panpsychism were divergent: from animism of primitive beliefs to developed idealistic teachings about the soul and mental activity as the true essence of the world (the concept of the monad by G. Leibniz, criticised by inter alia B. Russell[14]).

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12 C. Strom, *Was Socrates in Space? A Question of Ancient Spaceflight,* https://www.ancient-origins.net/unexplained-phenomena/ancient-spaceflight-0010517 (dostęp: 07.08.2021).

13 F. Shcherbakov, *Метафора космоса – как полиса в стоическом учении и его этико-коммуникативные следствия* [Metafora kosmosa–kak polisa v stoichceskom uchenii i ego etiko-kommunikativnye sledstviia], Philosophy, p.13.

14 „The Monadology was a kind of fantastic fairy tale, coherent perhaps, but wholly arbitrary". Cf. Introduction to B. Russell, A Critical Exposition of the Philosophy of Leibniz, Allen Unwin, 2nd ed., London 1937. Cited after: Stanford Encyclopaedia of Philosophy, https://plato.stanford.edu/entries/leibniz/ [Access: 15 October 2021]

K.E. Tsiolkovsky is an important figure in the Russian cosmism philosophy; he is the only thinker who called his humanitarian philosophy „cosmic". In his teaching, he considered many disciplines: ontology, epistemology, anthropology, theory of technology, theory of society[15]. The dominants of Russian cosmism, both in general and in Tsiolkovsky's teachings, include the following ideas: monism (the unity of the world and man in many manifestations of this unity); eternity of life in the universe in its various forms; evolutionism (evolution of spiritual substances, man, nature, society); coherence of man with space (self-renewal, autonomy in matters of physiological existence, immortality); expansion of human consciousness by combining historically and traditionally divided spheres of social consciousness; harmony of man and technology in technogenic variants of social theories; recognition of human society as a factor and phenomenon of a cosmic scale.

K. Tsiolkovsky put forward the following theory: the physical world consists of atoms that have a potential psychic sensitivity; the atom is immortal, lives the life of its specific appearance, travels from body to body with the help of the exchange of matter in nature[16] and the presence of an atom (with a constant change of bodies) in the composition of increasingly highly developed intelligent creatures to ensure a full-fledged conscious life in the human body.

HISTORY OF THE DEFINITION

The definition of „cosmos" (gr. κόσμος – the Universe) was first used in everyday life in the sense of any order, for example, in the sense of „smartness, beauty, moral dignity or education". Shame and justice, according to Protagoras, are the „cosmos"[17], that is, the decoration of the state. According to Democritus, „cosmos" is a state order, which is opposed to disorder, acosmia. The pre-Socratics used the term "cosmos" in the sense of „the world seed". Democritus called the „cosmos" a set of order consisting of bonds of atoms. Therefore, a person is called a „small cosmos" by him. Pythagoras was the first to use the term „cosmos" to refer to the world as a whole. For Philolaus, the term „cosmos" denoted the limited extent and order of the world as a whole, organized on the principle of harmony. The term „cosmogony" is first suggested by Plutarch. As for the essential difference between the concepts of „cosmos" and „chaos", it is characteristic of Hesiod in his „Theogony"[18].

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15 K. Tsyolkovski, *Очерки о вселенной* [*Ocherki o vselennoy*],Moscow, pub. Aleteya, 1999, p. 45.

16 K. Tsyolkovski, *Очерки о вселенной* [*Ocherki o vselennoy*],Moscow, pub. Aleteya, 1999, p. 46.

17 A. Lebedev, *Логос Гераклита:реконструкция мысли и слова* [*Logos Geraklita: rekonstruktsiia mysli i slova*], Saint-Petersburg, Science, 2014. p.120.

18 *Древнегреческие философы о космосе,как основе мировой жизни* [Drevnegrecheskie filosofy o kosmose, kak osnove mirovoi zhizni] https://studwood.ru/974136/filosofiya/drevnegrecheskie_filosofy_kosmose_osnove_mirovoy_zhizni (dostęp: 07.08.2021).

The primary ancient cosmos was represented by a spatially finite body. Even Aristotle denies the infinity of the cosmos on the grounds that man could not perceive any infinite body at all, since every body actually perceived by man is always finite, that is, it is the most ordinary, even if the most enormous, quantity. In the sense of time, the ancient cosmos is also finite. However, it can be destroyed and created. The creation of a new cosmos is nothing but a reproduction of the former cosmos. The ancient cosmos thus exists outside of time. It is absolutely not progressive, and no matter what changes occur in it, in the last analysis it is always the same, not only limited in space, but also in time, not allowing any progress whatsoever. The cosmos in such a representation is always given to a person visually in the form of a „picture" and sensually perceptible[19].

Homer uses the most subtle and vividly honed geometric representations. The vision on the basis of which Homer builds his cosmos is clear and distinct. His cosmos is an all-in-one living space. This vitality is also characteristic of all parts of the cosmos. In the Homeric cosmos, everything creates its own will, but this will serves to achieve one or another cosmic goal. Everything exists and acts decisively in everything. Every object in Homer's cosmos is therefore wonderful, and every hero is therefore superhuman, because they create one universal goal and reflect in themselves one universe, that is, one rational cosmic will. Homer's rational teleology of the cosmos and his extra-rational spontaneous uncertainty are combined into one system[20].

The identification of the universal mind and the universal destiny is nothing but an ultimate, universal cosmic phenomenon. This identity of the cosmic mind and the cosmic destiny follows by itself from the basic ancient intuition. The cosmos is beautiful, but this is the result not only of its universal intelligence, but also of its fatal destiny. Today it may be beautiful, but tomorrow it may fall apart and become ugly. And all this is also fine, legit, self-evident and natural. The teleology of the cosmos and its fatalism are the same thing for Homer[21].

The cosmos in the period of the early ancient classics does not deny gods, demons and heroes, but uses them only attributively, so that the cosmos itself is interpreted not in its absolute reality, but in its predominantly objective reality. The myth is gradually losing its humanoid basis. There is an idea of the elements, that is, of what is seen and heard, and even quite animate, quite vital, but no longer human-like. This was the moment of birth of a philosophical theory that arose as the doctrine of the elements and the information of the cosmos on the life of these elements.

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19 Aristoteles, *Сочинения*, [*Sochineniia*], Moscow, pub. Thought, 1976, p. 84.

20 F.O. Shelling, *Философия искусства* [Filosofiia iskusstva], Moscow, pub. Thought, 1999, p. 120.

21 K. M. Vogt, *Law, Reason, and the Cosmic Sity. Political Philosophy in the Early Stoa,* pub. Oxford: University Press, 2008, p. 15.

Among the primary elements there are: earth, water, air, fire, and ether. According to Empedocles, all the elements are combined into a single cosmos. The primary element is water – for Thales, air – for Anaximenes, fire – for Heraclitus. The cosmos continues to be thought of as something alive and many philosophers talk about the breathing of the cosmos. According to Empedocles, the breath passes through the whole world like a soul. According to Philolaus, the cosmos is also permeated through and through by the „breath of nature"[22]. Life was thought of so intensely that it was definitely characterized as an immortal soul that continues to live even after the death of the body. Having lost its humanity, the cosmos has turned into an active, creative, dynamic structure of the universe. Dynamically directed Pythagorean numbers appear in the minds of philosophers of the early classical period. This was also the logos of Heraclitus. This was the thinking of Diogenes of Apollonia, represented in the form of air[23].

The principle of the actual structural design of the cosmos – numbers, logos, thinking process, geometrically correct bodies – created such a picture of the eternal struggling of the elements, in which the cosmos was no longer any different from chaos and which, at most, led only to an eternal change from chaos to cosmos and from cosmos to chaos. Parmenides said that only thanks to the cosmic order, existence can neither disperse nor unite. According to Heraclitus, without the formalising principle, the most beautiful cosmos would have turned into a pile of garbage[24]. Therefore, the goal of human life is nothing more than the contemplation of the order of the cosmos (Anaxagoras)[25].

Pythagoras was the first to call the „circle of everything" as the cosmos because of its ordering[26]. The Pythagoreans had the idea of the dependence of the globularity of the cosmos on the mind, the imitation of which the cosmos is. In fact, there was already a dialectic of the cosmos lying here, which appeared in a developed form only according to Plato. Namely, that the cosmic mind surveys the entire cosmos at once and instantly, immediately returning to the point from which it begins to consider the cosmos. This circumstance also makes the entire cosmic region return to its shape, that is, spherical[27].

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22 E. Tseller, *Очерк истории греческой философии* [Ocherk istorii grecheskoi filosofii], Saint-Petersburg, pub. Aleteya, 1996, p. 20.

23 E. Tseller, *Очерк истории греческой философии* [Ocherk istorii grecheskoi filosofii], Saint-Petersburg, pub. Aleteya, 1996, p. 20.

24 G.E.R. Lloyd, *Polarity and Analogy. Two types of argumentation in early Greek thought*, pub. Cambridge, University Press, 1966, p. 13.

25 E.D. Sylla, *Natural philosophy, medieval,* Routledge Encyclopedia of Philosophy, 1998, p. 5.

26 E.D. Sylla, *Natural philosophy, medieval,* Routledge Encyclopedia of Philosophy, 1998, p. 5..

27 *Древнегреческие философы о космосе,как основе мировой жизни* [Drevnegrecheskie filosofy o kosmose, kak osnove mirovoi zhizni] https://studwood.ru/974136/filosofiya/drevnegrecheskie_filosofy_kosmose_osnove_mirovoy_zhizni (dostęp: 07.08.2021).

According to Empedocles, the shape of the cosmos is ovoid[28]. Anaximander also thinks of the Earth as rounded, curved, like a segment of a stone column or a cylinder. Ferekid has an image of the cosmos in the form of a cave. The authorship of this widespread image is also attributed, most often to Plato, however Porphyry attributes it to Pythagoras. In addition to geometric figurativeness, the cosmos was also understood with the help of such a powerful category as a „vortex"[29]. The cosmic force of Enmity, according to Empedocles, exists in the form of „vortices of the ether", which throws an evil demon into a constantly rotating circle of mutually transitive elements. Empedocles' vortex is a cosmic abyss that is in constant motion. The nature of this movement changes to the opposite depending on what is in the center of the cosmos – Friendship or Enmity, so that in the central position of Friendship, the vortex acts centripetally, contributing to the formation of integrity, and in the central position of Enmity, the vortex acts centrifugal, destroying this integrity of the cosmos[30]. Thus, in the cosmic plane, the vortex occupies a position even more primary than Friendship and Enmity. The category of the vortex was especially important for the atomist Democritus. Everything „happens out of necessity, and the cause of all things is a vortex". The vortex for atomists is only a picture of the movement of atoms, but not their real movement[31].

Giving a visual picture of the cosmos, the philosophers of the early classics actively use the concept of the infinite. From the action of the limit principle, the cosmos itself and all its constituent parts, outlined against an infinite background. According to Leucippus, the cosmos is a segment of the infinite, and therefore there can be an infinite number of cosmoses.

Pythagoreanism, which developed in the field of the dialectic of numbers and figures, is the basis, the predecessor of Platonism. The discovery of ultimate generalities, or categories, was carried out by Socrates. This was the beginning of a critical conceptual analysis of the cosmos, replacing its intuitive descriptive forms, and of the logical dismemberment and dialectical reunion of the dismembered elements. The cosmos received a new characteristic, developed primarily by Plato. Platonic community also has its own materiality, corporeality, but only not of a sensual nature, but purely semantic, purely mental. The difference between the intelligible cosmos, according to Plato, from the sensual one lies only in the

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28 *Древнегреческие философы о космосе,как основе мировой жизни* [Drevnegrecheskie filosofy o kosmose, kak osnove mirovoi zhizni] https://studwood.ru/974136/filosofiya/drevnegrecheskie_filosofy_kosmose_osnove_mirovoy_zhizni (dostęp: 07.08.2021).

29 *Древнегреческие философы о космосе,как основе мировой жизни* [Drevnegrecheskie filosofy o kosmose, kak osnove mirovoi zhizni] https://studwood.ru/974136/filosofiya/drevnegrecheskie_filosofy_kosmose_osnove_mirovoy_zhizni (dostęp: 07.08.2021).

30 T.V. Vasilieva, *Поэтика античной философии* [Poetika antichnoi filosofii]. Moscow, pub. Academic Project; Triksta, 2008, p. 10.

31 T.V. Vasilieva, *Поэтика античной философии* [Poetika antichnoi filosofii]. Moscow, pub. Academic Project; Triksta, 2008, p. 10.

fact that its cosmos has brighter sensual colors, in their much more beautiful arrangement and in the absence of any obscuring moments and any earthly imperfections[32].

Plato's Eidos (idea, form) acts as a parent, and matter as a mother, and real things are the product of Eidos and matter. This idea is most stable in antiquity; even according to Plotinus the primary generative principle is characterized as the „father", the intelligible cosmos as the „son" and the sensory cosmos as further products of the intelligible cosmos. This is the initial intuition of the entire ancient worldview.

Very quickly, the early Greek thinkers came to the realisation of this possibility – the conceptualisation of the whole world through a metaphor. J.E.R. Lloyd[33] identifies three central metaphorical models within which the cosmos was conceptualized:

- sociomorphic (where cosmos is polis);
- technomorphic (where cosmos is craft, art);
- biomorphic (where cosmos is a living being; an entity, a person).

The idea of Cosmopolis (cosmos as a polis, which usually interpreted as a stoic concept) is explicitly expressed by the cynic Diogenes of Sinope, who was the first to call himself a citizen of the world, answering the question „where is he from?" [34], although he used this expression in a completely different sense than his closest disciple Zeno. Cosmopolitanism in the cynical sense is a refusal to obey precisely the norms, customs and laws of a polis society. The Russian researcher V. V. Brovkin also believes that the ethics of Stoics was inconsistent and contradictory, because it contained two completely incongruous tendencies: radical – cosmopolitan and protective – conservative[35].

Protective – conservative attitude of the Stoic school has great influence on the concept of Hugo Grotius Mare Liberum[36]. This concept, in turn, inspired contemporary regulation of the outer space, which is guaranteed by all modern legal acts.

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32 T.V. Vasilieva, *Поэтика античной философии* [Poetika antichnoi filosofii]. Moscow, pub. Academic Project; Triksta, 2008, p. 10.

33 G.E.R. Lloyd, *Polarity and Analogy. Two types of argumentation in early Greek thought*, pub. Cambridge, University Press, 1966, p. 16.

34 O.M. Freidenberg, *Миф и литература древности* [Mif i literatura drevnosti], Moscow, Science, 1978, p. 23.

35 V.V. Brovkin, Ранние стоики: космополитическая доктрина и политическая практика [Rannie stoiki: kosmopoliticheskaia doktrina i politicheskaia praktika], „Vestn. Novosib. gos. un-ta. Seriia: Filosofiia", 2014/3, p.155.

36 For instance, M. Polentz, speaking about the nature and ethical consequences of this teaching, also notes: "This picture of the world was anthropocentric and retained its religious significance both for the Stoic and for the Middle Ages" – M. Polents, *Стоя. История философского движения.* [Stoia. Istoriia dukhovnogo dvizheniia], Saint-Petersburg, pub. Quadrivium, p. 32.

MODERN REGULATION OF THE COSMIC SPACE

Existent international legal system brings together many legal acts dedicated to the regulation of the outer space exploration and usage. We can name such documents as:

1. The Moon treaty (Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, 1979);
2. The Outer Space Treaty (Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies,1967);
3. Convention on International Liability for Damage Caused by Space Objects (Space Liability Convention 1972) etc.

The exploration and use of outer space inevitably inclines the international community to the need to define common principles, rules and mechanisms for this activity. Cosmos and objects of outer space were declared as a value, as an object of preserve. Hence, we can see a lot of similarities in the cosmic space regulation and regulations on natural resources and objects of nature (most of all – the law of the sea).

As we know, the concept of free seas, which originates in the XVII century, eventually took a dominant position and now forms the basis for the study and use of the oceans. It should be noted that one can find quite a lot of similar mechanisms in the legal regulation of maritime and outer space, for example, their fixed extraterritorial status. The regulation of the outer space experienced some influences of the philosophical concepts which were mentioned above. In the context of the increasing presence of humanity in space, it is possible to hear a statement about the need to expand the jurisdiction of the state over outer space objects (lat. Astra Clausum, understood as the concept of „closed" space). On the other hand, despite such discussions, the concept of „free" space remains dominant. It is safe to say that Astra Clausum vs. Astra Liberum, represent two key approaches, which are at the same time a kind of social contract regarding the presence of man in space. This discussion can also be considered in the context of competition of concepts: that of the consolidated sea by Hugo Grotius, better known as Mare Liberum, with the concept of the closed sea by John Seldon (lat. Mare Clausum)[37].

Regardless of the fact that many international documents are dedicated to exploration and use of the outer space, none of them provided criminal responsibility of natural persons for outer space exploration regulation infringement. The Moon Treaty (Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, 1979) provides some very important guarantees:

[37] A more detailed review of the concepts of *Astra Clausum* and *Astra Liberum can be found* in relevant articles of Dr. P. Chyc.

- it provides a framework of laws to establish an international cooperation regime, including appropriate procedures, to govern the responsible exploitation of natural resources of the Moon. (Article 11.5);
- it forbids any military use of celestial bodies, including weapon testing, nuclear weapons in orbit, or military bases. The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited. (Article 3.4).
- it forbids altering the environmental balance of celestial bodies and requires that states take measures to prevent accidental contamination of the environments of celestial bodies, including Earth. (Article 7.1);

The Outer Space Treaty, formally the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967), also provides system of outer space usage and exploration guarantees. The treaty explicitly forbids any government from claiming a celestial body such as the Moon or a planet. Article II of the treaty states that „outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means". However, the state that launches a space object retains jurisdiction and control over that object.

The state is also liable for damages caused by its space object. As for national legislations – none of the countries expands criminal liability for their citizens in these cases. Superficial analysis already shows that at the moment only the general rules for the use of outer space, which form the basis of its international legal regime, have been settled. However, the principles of freedom and prohibition of the appropriation of outer space in modern realities raise more and more questions, requiring particularly detailed regulation.

For many years, natural persons and private entities had been excluded from outer space exploration, however times has changed strongly. The Outer Space Treaty does not consider natural persons' participation in space exploration. This fact is used by the United States, unequivocally claiming that, in its current form, the prohibition on the appropriation of celestial bodies and their resources applies only to states[38], and not to private entities involved in space exploration.

Secondly, the problem of regulating the use of space minerals for commercial purposes should also be noted. Since international legal acts contain norms exclusively on the possibility of using natural space resources for scientific research, while limiting themselves to the general standards contained in the Outer Space Treaty, as well as in the Agreement on the Activities of States on the Moon and Other Celestial Bodies, the possibility of using minerals in any commercial activity remains unresolved.

It should also be emphasized that the Agreement on the Activities of States on the Moon and Other Celestial Bodies concluded within the framework of the UN on

[38] This analysis of this concept was precisely considered in relevant articles of dr. P. Chyc.

December 18, 1979 (the Moon Treaty) considers the Moon and its natural resources to be the common heritage of mankind, which restricts the freedom of its use by establishing state sovereignty on part of its territory, and also provides for the principle of international control over the use of natural resources of the Moon[39].

The concept of the world unity finds its apogee in these international documents. If everyone has the same amount of rights to the outer space then no-one could become its owner. As stoic concepts of the world and universe were based on the assumption that elements of the world could not be considered as someone's property (natural person could only possess them for short period of time), the Outer Space Treaty (and the Moon Treaty) creates the system where none of the celestial bodies could become a property of any state.

Due to the level of technical progress, these documents could not predict the possibility of private persons to become participants of the outer space exploration activity. Hence, worthy of greater attention is the problem of the „lack of the responsibility" in the legal regulation of the outer space exploration. For the time being, natural persons are „excluded" from legal liability for the cosmic pollution or usage of space for military goals (or maybe it is more appropriate to say that their actions are indifferent for the existing legal system). But given the growing participation of private subjects in outer space – related activity, there is urgent need to tackle this problem. Currently, no country provides criminal liability for malicious activity during the outer space exploration or usage.

Taking necessary action seems inevitable. Right now only states are subjects responsible for all space objects that are launched within their territory. This means that regardless of who launches the space object, if it was launched from a state territory, or from state facility, then that state is fully liable for damages that result from that space object. Claims could be provided only between a state and against a state.

The Convention on International Liability for Damage Caused by Space Objects, also known as the Space Liability Convention does not provide any possibility for natural persons to become liable for economical, organizational or scientific activity. In order to complete the above brief analysis of contemporary legal international regulation of the exploration and usage of the outer space, mention should be made that provisions of these legal acts create a system of declaratory rules which are paradoxically very similar to the ancient Greek school of Stoic principles of the human being in constant interaction with the entire world. Hence the problem of lack of precise rules – a philosophical concept requires much less specification, but the absence of particular legal norms creates major gaps in the legal system.

Changes made exclusively in international legal documents will not be sufficient. State liability is obviously not adequate given contemporary technical de-

[39] https://www.un.org/ru/documents/decl_conv/conventions/moon_agreement.shtml (dostęp: 07.08.2021).

velopment and suitable changes on the national levels would be also necessary. The current situation when a state is the only subject of regulation as regards liability for actions of its citizens in outer space can not be considered as a logic or sufficient from two points of view.

Firstly, the real perpetrators should be brought to justice in case of violations. For example, a natural person capable of outer space exploration activities (for example mining and mineral extraction on the celestial bodies) in case such activity causes irreversible damage of the unique nature of space objects (which constitute the common heritage of mankind) will not bear any other responsibility except civil sanctions, which, it is submitted, cannot be considered as adequate guarantee, while legislations do provide for criminal liability for individuals for environmental crimes. Secondly, there is a possibility that individuals if freed from liability will become avid accomplices of unscrupulous states in malicious space exploration.

CONCLUSIONS

Existent regulation of outer space exploration seen as continuation of Tsiolkovski's theory of „monism" and the stoic's concept of „Cosmopolis" could not be considered as sufficient. High level of social value of the celestial bodies and outer space has not been reflected in adequate legislative guaranties. This situation will inevitably pave way for the changes not only of content in some international agreements, but, as has already been mentioned, it determines appropriate changes in civilized legal systems and – primarily – in adequate criminal law regulations. But, as stated at the outset – the perception of cosmos is a typical reflection of a society by its members. Current legislation creates the possibility for outer space rivalry among states and that is what we should be aware of.

As mentioned above, the perception of cosmos has changed throughout centuries. We are facing a new era of outer space regulation – the time when private persons are starting to become participants of outer space exploration. From the theoretical perspective, this has already been predicted by Greek philosophers (and even analyzed by them in a certain way) in the concepts of Fate according to Homer, the Stoic idea of Cosmopolis, and animistic traditions' concepts, which – I contend – could inspire new generation of legislative acts in the field of outer space exploration.

In this article I tried to demonstrate the kinship of modern legislative principles with some philosophical traditions, as far as existing law was formed with the influence of many concepts and ideas. Hence, I suggest that sometimes to understand the direction of our development we need to refer to our past; otherwise we will never reach the desired goals. The effectiveness of the cosmic regulation depends on what type of our social reflection will we see in the outer space.

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LEGAL ACTS

The Moon treaty (Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, 1979);
The Outer Space Treaty, formally the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967);
Convention on International Liability for Damage Caused by Space Objects, also known as the Space Liability Convention (1972).

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THE IMPACT OF THE FOURTH INDUSTRIAL REVOLUTION ON LAW – CIVIL LIABILITY FOR DAMAGE CAUSED BY ARTIFICIAL INTELLIGENCE SYSTEMS[1]

Abstract: The author attempts to present, in a synthetic and general way, the impact of the fourth industrial revolution on the law, with particular emphasis on the impact on the issue of civil law liability, considering it one of the fundamental ones in the face of this revolution. The intensity and multi-facetedness of the changes resulting from the dynamic technological progress affects practically every area of social and economic life and legal systems. The study aims to briefly present views and perspectives of upcoming changes in the law, mainly in the aspect of possible civil law liability for damages caused by artificial intelligence systems in the EU legal system.

Keywords: fourth industrial revolution, industry 4.0, law, artificial intelligence, civil liability, damage.

INTRODUCTION

The development of civilization has always been a direct or indirect result of technical progress, progress in research and science. The Fourth Industrial Revolution (Industry 4.0) is ongoing and is driven by digitization, data and artificial intelligence (AI). Modern technologies using artificial intelligence will be widely used in every segment of socio-economic life. Examples include: communications, health care, transport, agriculture, environment, management, security, maritime and space industries, and public services.

[1] The Polish version of this chapter has been publicated in D. Wetoszka (ed) Prawo gospodarcze, C. H. Beck, Warszawa 2020.

According to Dave Coplin, Microsoft's main visionary, "artificial intelligence is the most important technology in the world today"[2]. This thesis is confirmed by public and private funds invested in the development of artificial intelligence. In 2016, this investment amounted to 3.2 billion euros in Europe, 12.1 billion euros in North America and 6.5 billion euros in Asia[3]. During the next decade, the European Union plans to make a total investment of more than 20 billion EUR each year[4]. In addition, the availability of financing in the field of Artificial Intelligence for the SME sector will be increased under the EU's InvestEU programme[5]. In turn, the American company SpaceX – whose founder and president is Elon Musk – will spend about 10 billion dollars to create the Starlink system, which aims to provide access to fast and cheap Internet covering the whole globe – without exceptions, and in the future to transmit the network also to Mars[6]. This will transform mobility of people and devices on an extraordinary scale.

The economy based on industry 4.0 is a civilizational opportunity for further development of mankind and improving the quality of life, but also entails a myriad of resulting threats. Every "revolution", by its very nature, consists of a multitude of rapid changes. Thus, the fourth industrial revolution will lead to a reshaping of the social and economic structure, and possibly also of the political structure – the scale and depth of which we are currently unable to assess precisely.

CHALLENGE TO THE LAW

The most complex, but also the most important challenge, is to properly direct the process of the contemporary technological revolution[7] in such a way, that human being and service to society are at its center. This unique "challenge" must be faced by law. Legislation, including continental Europe, will be compelled to create a new legal and institutional framework that responds to the needs of an innovative economy and the development of 4.0 technologies, while safeguarding a widely recognized system of values and human rights.

The new regulations should, in a way, have a servant role towards technology (to provide an impulse for development) and be flexible enough to define the unpredictable (artificial intelligence). At the same time, the law should harmoniously but as effectively as possible protect the system of values and human rights as the primary role of law in every aspect.

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2 S. Shead, *Sztuczna inteligencja to najważniejsza z obecnie rozwijanych na świeci technologii*, https://businessinsider.com.pl/technologie/nowe-technologie/sztuczna-inteligencja-to-najwazniejsza-rozwijana-obecnie-technologia/qscny5j [accessed on: 21.03.2020].

3 *COM(2020) 65 final.*

4 *Ibidem.*

5 *Ibidem.*

6 M. Pluskota, *Skąd weźmiemy internet na Marsie?*, "Świat Wiedzy. Kosmos", 2020, nr 2, p. 24–

7 K. Schwab, *Czwarta rewolucja przemysłowa*, Studio EMKA, Warszawa 2018, p. 17.

The fourth industrial revolution will, therefore, affect the order of legal systems and legal thought. The widely known different concepts – what is not prohibited, is allowed, and what is not explicitly allowed, is prohibited – will have to be combined in order for the new legislation to create "the most secure space for innovation to emerge"[8]. Success in transition to economy 4.0 will be achieved by those legislators and those societies whose legislation will be able to make laws that fully adapt them in the area of rapidly changing innovative technologies[9].

The implementation of appropriate legal policies will become one of the most important determinants of success of this revolution. The main areas to be regulated by lawmakers in the field of artificial intelligence can be defined as: prevention, supervision and responsibility. The continental law system is also facing such a challenge.

THE PERSPECTIVE OF EUROPEAN UNION LAW POLICY ON ARTIFICIAL INTELLIGENCE

The European Union is working intensively to create regulations to regulate the area of artificial intelligence. Aiming to be one of the world leaders in the development and use of AI in the economy, the Union should work out legal solutions that will be uniformly applicable throughout the Community in order to preserve the values of legal security, legal certainty and competitiveness in the global economy. The European Parliament adopted in 2017 a resolution with recommendations to the Commission on civil legislation on robotics (2015/2103(INL))[10]. Artificial intelligence will affect the greatest number of changes in precisely the branch of civil law (e.g. liability, AI development, research and innovation, intellectual property rights, data flow and protection, insurance). In this resolution, Asimov's rights are considered fundamental among the general principles:

- First Law: A robot may not harm a human being or, by failing to act, allow a human being to be harmed.
- Second Law: A robot must obey human orders, unless they conflict with the First Law.
- Law Three: a robot must protect itself unless it contravenes the First or Second Law.
- Zero Law (overriding): A robot must not harm humanity, actively or by negligence.

The starting point for all relevant legislative processes is the definition of artificial intelligence. The EC Communication on Artificial Intelligence for Europe

[8] *Ibidem*, p. 94.
[9] *Ibidem*, p. 98–100.
[10] European Parliament resolution of 16.2.2017 with recommendations to the Commission on civil law provisions concerning robotics (2015/2103(INL)) (EU Official Journal C 252/239).

of 2018 proposed a definition of AI: "The term artificial intelligence refers to systems that exhibit intelligent behavior by analysing their environment and taking action – to some extent autonomous – to achieve specific goals. AI systems can be software-based, operating in a virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems), or they can be embedded in devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications)"[11]. The High Level Group of Experts elaborates on this concept as follows: "Artificial Intelligence Systems (AI) are human-designed software (and possibly computer hardware) that, in order to achieve a complex goal, operates in a physical or digital dimension, perceiving its environment by acquiring data, interpreting the collected data (structured or not), drawing conclusions from that data or processing information from that data and deciding on the best action to take to achieve that goal. Artificial intelligence systems can use symbolic principles or learn from a numerical model and can also adjust their behavior by analyzing the environmental impact of their previous actions[12].

In addition, the European Commission published a White Paper on Artificial Intelligence in February 2020. A European approach to excellence and trust[13]. The White Paper sets out in detail the current state and use of artificial intelligence in the EU, development prospects, opportunities and threats, the current state of the law and the directions that EU legislation should take when setting standards in the field of AI.

The issues of safeguarding the catalogue of EU values and fundamental rights, including protection of personal data, privacy and non-discrimination, as well as consumer rights, security and accountability, have been identified as strategic for regulation. Currently there is no common European legal framework that would create a unified legal order to minimize the various potential risks of artificial intelligence[14]. The White Paper sets out the horizons of work on these regulations, which will be harmoniously supported by the already existing EU legal acts (e.g. Consumer Rights Directive No 2011/83/EC, Directive No 2019/882/EU on requirements for the availability of products and services).

CIVIL LIABILITY IN THE FACE OF ARTIFICIAL INTELLIGENCE

One of the most fundamental issues to be regulated in civil law is liability for damage caused by AI systems. Artificial Intelligence is not fully predictable – we know the potential risks, but not all of them. We have the ability to only partially

11 *COM(2018) 237 final.*
12 *Ibidem.*
13 *COM(2020) 65 final.*
14 *Ibidem.*

predict the behavior of AI, and not the final actions, so the extreme possible damage (e.g. personal injury, material and non-material damage).

The use of artificial intelligence in products and services is becoming increasingly common. It is predicted that by 2025 the proportion of data processing and analysis by intelligent objects connected to the Internet will increase significantly in the EU[15]. Research by the World Economic Forum (WEF) shows that the majority of world business leaders (79%) predict that by 2025 10% of vehicles on U.S. roads will be autonomous[16]. The state of Nevada (USA) has already passed a law in 2012 to allow the participation of autonomous cars in road traffic[17]. Autonomous vehicles are also the near future in Europe. Meanwhile, European seaports are already using AI in their infrastructure and are testing further application possibilities (e.g. Port of Hamburg)[18]. Partially or fully autonomous seaport quays are a matter of the coming years.

There are a lot of examples of practical and everyday use of artificial intelligence, such as the above. At the same time, there are many risks associated with this. In 2016, for the first time, a fatal accident involving an autonomous vehicle took place – during a Tesla test, the driver of the vehicle tested in autonomous mode was killed on site[19]. Another fatal accident occurred in 2018, where pedestrian was hit-and-run by an autonomous vehicle belonging to the company Uber[20]. From this perspective, the need for legal regulation of civil liability is becoming even more urgent. According to the report on the impact of artificial intelligence, the Internet of Things and Robotics on safety and liability, traditional concepts in most EU Member States national liability laws can be ineffective and complicate claims[21].

The institution of legal civil liability for damages in the system of continental law (e.g. unlawful damage to someone else's property – damnum iniuria datum), including the formation of a subjective premise of liability (guilt of the perpetrator), has its roots in the jurisprudence of ancient Rome and Roman law (delicta privata)[22]. Today, this is accepted and constituted in many European legislations,

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15 *Ibidem*.

16 K. Schwab, *Czwarta rewolucja przemysłowa*, Studio EMKA, Warszawa 2018, p. 177.

17 A. Knapp, *Nevada Passes Law Authorizing Driverless Cars*, https://www.forbes.com/sites/alexknapp/2011/06/22/nevada-passes-law-authorizing-driverless-cars/#43f1f1951332, [accessed on: 22.03.2020].

18 F. Wolski, *Port Hamburg pracuje nad wykorzystaniem autonomicznych pojazdów*, https://www.rynekinfrastruktury.pl/wiadomosci/porty/port-hamburg-pracuje-nad-wykorzystaniem-autonomicznych-pojazdow-68865.html, [accessed on: 22.03.2020].

19 J. Dybalski, *USA. Pierwsza piesza ofiara samochodu autonomicznego*, https://www.transport-publiczny.pl/mobile/usa-pierwsza-ofiara-samochodu-autonomicznego-auto-ubera-przejechalo-piesza-58039.html, [accessed on: 22.03.2020].

20 *Ibidem*.

21 *COM(2020) 65 final*.

22 W. Rozwadowski, *Prawo rzymskie. Zarys wykładu wraz z wyborem źródeł*, Ars Boni et Aequi, Poznań 1992, p. 194–202.

including Polish civil law, responsibility *ex delicto*. It is regulated by articles 415–449 of the Civil Code. On the basis of these provisions, tort liability may be incurred on the basis of the principle of fault (the general principle)[23], the principle of risk, the principle of equity and the principle of absolute liability. However, with regard to certain characteristics of artificial intelligence in its broadest sense, such as the unpredictability, non-linearity and non-transparency of the possible behavior of the products, it may be highly difficult or impossible to establish and properly analyze the sequence of facts from human behavior (e.g., the owner or operator of the device) to the given damage caused by the AI device, which would allow the subsuming of these provisions and the attribution of liability to the "perpetrator". It should also be borne in mind that the AI systems are not granted legal personality. Moreover, according to the wording of Article 415 of the Civil Code and in conjunction with Article 6 of the Civil Code, the burden of proof (onus probandi) rests with the injured party, where demonstrating, for example, the existence of a causal link, or the fact of a causal relationship, if possible in general, will at least make it more difficult to document the evidence and significantly increase costs for the injured party, thus limiting the possibility of effectuating claims and exercising rights. Nevertheless, in the case of damage caused by an artificial intelligence device, it will often be unrealistic to demonstrate this adequate causal link.

In the United Kingdom, legislation, including liability issues, is being developed as part of the Autonomous Car project. The project assumes the application of strict liability, i.e. granting the owner or insurer responsibility for damages caused by the autonomous car[24]. Legislative activities in this area are also conducted in the USA. Unification of regulations at the federal level requires, for example, a widespread share of autonomous cars in road traffic, and nowadays it is the individual states that create their own regulations (e.g. the mentioned Nevada). Broad discourse on this subject is not clear. The doctrine of American civil law is dominated by the views pertaining to limit manufacturer's liability, even though it seems to be the most legitimate[25] and it is possible that it will eventually adopt this formula – new regulations are being developed by the Congress[26].

The analysis of the possibilities and establishment of specific standards is also desirable in the EU. Legal certainty in the area of AI is expected by Member

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23 W. Czachórski, *Zobowiązania. Zarys wykładu*, Wolters Kluwer, Warszawa 2009, s. 212.

24 Ł. Łyczko, *Sztuczna inteligencja – kluczowe aspekty prawne*, https://www.pwc.pl/pl/artykuly/2018/sztuczna-inteligencja-kluczowe-aspekty-prawne.html, [accessed on: 23.03.2020].

25 M. Czenko, *Odpowiedzialność za szkodę spowodowaną ruchem pojazdu autonomicznego w systemie amerykańskiego prawa cywilnego* [w:] *Zeszyt Studencki Kół Naukowych Wydziału Prawa i Administracji UAM*, red. M. Jędrzejczak, Wydawnictwo Naukowe Uniwersytetu im. Adama Mickiewicza, Poznań 2017, s. 115.

26 W. Czekacz, *W USA trwają pionierskie prace nad przepisami dot. korzystania z autonomicznych samochodów*, https://itwiz.pl/usa-trwaja-pionierskie-prace-nad-przepisami-dot-korzystania-autonomicznych-samochodow/, [accessed on: 23.03.2020].

States, businesses, consumers and many others. One of the concepts is to include damages caused by AI systems within the legal regime of strict liability (aggravated liability), similarly to the British concept (blameless liability). This would eliminate the obligation for the injured party to demonstrate an adequate causal link in the occurrence of damage, and would clearly identify the liable party in the form of the owner or operator of the equipment in question or insurer assuming responsibility through a separate contract. However, an extended analysis should be made of the socio-economic impact and the optimality of the possible application of such a solution in the European system (e.g. slowing down technological development and market innovation, discouraging consumers). It seems unlikely that the EU would choose to accept such a liability structure.

By interpreting the official positions and communications and legal acts issued within the EU to date, it can be concluded that they aim at a different way of shaping the issue of responsibility than the one described above on the model of the British assumption. The civil liability for damage caused by an AI device is most likely to be attributed to the product manufacturer. Initially, this will be done by closing the gaps, strengthening, extending and regulating the existing legal framework, such as Directive 85/374/EEC on liability for defective products (OJ EU L 210/29), Directive 2001/95/EC on general product safety (OJ EU L 11/4), or Directive 2006/42/EC on machinery (OJ EU L 157/24). This thesis is confirmed in particular by the conclusions of the mentioned Communication on artificial intelligence for Europe[27] or the White Paper[28]. Under the Directive 85/374/EEC on liability for defective products, the manufacturer or importer is liable for damage regardless of negligence or guilt. However, due to its characteristics, artificial intelligence requires a review of views and adaptation to dynamic and thus changing technological development, especially in the subject of the injured party's proving the defectiveness of the product and demonstrating an adequate causal link, as well as in the matter of exonerational premises exempting the producer from liability.

In Polish civil law, liability for damage caused by a hazardous product is regulated in the provisions of art. 449^1-449^{11} of the Civil Code. These regulations are fully harmonized with the EU law. The prerequisites for producer's liability are defined as follows: the manufacture and placing a hazardous product on the market within the scope of the manufacturer's business activity, occurrence of damage and an adequate causal relationship between manufacture and introduction of the product on the market and the damage. The injured party is obliged to prove the fact of manufacturing a dangerous product, the damage and an adequate causal relationship between the product properties and the damage. The relationship between the manufacture and marketing of a dangerous product and the manufacturer's business activity a subject of legal presumption.

27 *COM(2018) 237 final.*
28 *COM(2020) 65 final.*

Exonerating premises include: disclosure of dangerous properties of the product after it has been placed on the market; inability to predict dangerous properties of the product, taking into account the state of science and technology („state of the art") at the time of placing the product on the market (the so-called development risk)[29]; creation of dangerous properties of the product as a result of applying legal regulations. The example of the implementation of the existing EU legal framework into national laws, in this case the Polish Civil Code, further highlights the shortage of applicable standards and the need to create clear regulations in the field of artificial intelligence.

CONCLUSION

At the present stage of development, it is reasonable to strive for the most urgent and effective action to establish a single European Union regime of responsibility for the operation of artificial intelligence systems, based on the adaptation and extension of regulations, inter alia, in the area of responsibility for a dangerous product, placing this responsibility on the manufacturer. The applicable provisions must be updated in accordance with the needs resulting from the specificity of AI systems' functioning, i.e. the completely altered – so far not taken into account – model of ensuring safety, protection of fundamental values and individual rights of stakeholders and parties to legal transactions. Due to the complex, multi-entity and complex supply chain, the possible liability of the actors involved, e.g. the importer or the seller, may also be subject to further reflection in the future.

However, it seems rational to assign responsibility to the manufacturer, as it is him who has the greatest impact on the AI product and will potentially benefit most from its marketing. The present study is intended to showcase only some of the views on the multiplicity of changes occurring as a result of the fourth industrial revolution, which are not indifferent to the law. What is more, they pose a specific challenge to the law. Currently, within the framework of the European Commission preparatory, pre-legislative works, a solution consisting in updating and extending the already existing legal framework to include the issue of artificial intelligence is undergoing an in-depth assessment of its legitimacy, proportionality, adequacy and effectiveness. In these considerations, the attribution of liability for damage caused by AI systems to the manufacturer is considered as a necessary and optimal solution. However, technological developments and artificial intelligence in the future may underline the need for a separate liability regime for damages caused by AI, which may have to be postulated already now in a broader de lege ferenda perspective.

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[29] W. Czachórski, *Zobowiązania. Zarys wykładu*, Wolters Kluwer, Warszawa 2009, p. 300.

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CHALLENGES ASSOCIATED WITH DEVELOPMENT OF AUV – UNMANNED AUTONOMOUS UNDERWATER VEHICLES TO BE OPERATED USING THE AI-BASED CONTROL SYSTEMS

Abstract: This paper presents a general scientific approach to further development of the AUV autonomous Underwater Vehicles equipped with a novel control system based on the artificial intelligence (AI) methodology. It is shown with the paper that it is relatively easy to develop an idea of autonomous underwater vehicles but it seems to be a difficult task to reach a level of the AUV application indeed. First of all the paper presents a general approach to the AUV vehicle design. Then a more complex approach to the AUV vehicle design which is based on the performance-oriented risk-based method is described. All such the drives are presented within the paper. The key solutions regarding the concept of mini-brain control system for the AUV-AI-based vehicle is described. The preliminary results of research in this are shown. In the final part of paper the scientific and practical conclusions are given

Keywords: unmanned vehicle, AUV – autonomous underwater vehicle, control system, AI – artificial intelligence, AUV-AI-based mini-brain control system

INTRODUCTION

The last decade has been devoted to further development of the UUVs, or unmanned underwater vehicles, which may be of two types: the USVs – unmanned surface vehicles and UUVs – unmanned underwater vehicles. There is a growing interest in creating and implementation of fully advanced AUVs,

or autonomous underwater vehicles. The main drivers for the development of such vehicles are technologies of autonomous systems, sensors and effectors, innovative materials including the nano-materials and "intelligent" materials, innovative energy supply sources, innovative propulsion systems combining the efficient and silent engines and propellers, innovative IT technologies, including the double mode air-underwater control, and, finally, navigation and communication systems. Additional features the AUV vehicles may possess are the stealth--based and bio-technology-based solutions.

Commercial applications of AUVs cover conventional patrol and reconnaissance tasks. The navy-devoted AUV may enable reconnaissance and combat missions. Regardless of the application, it is necessary to implement advanced on-board hardware and software solutions to provide a high level of autonomy to the vehicles. The general requirements to obtain an autonomous AUV are concentrated on its autonomy from the energy supply, but also on self-control and self-navigation. It may be associated with not using communication with the center of mission; such a level of autonomy requires innovative solutions concerning the vehicle's sensors, effectors and control. The biggest challenge associated with the AUV development is to work out and implement an intelligent vehicle. A major difficulty to obtain such a vehicle is to acquire precise data from the surrounding environment, to process this data and to use it to perform all the tasks and mission in real time. The AU-AI-based vehicle should be equipped with a sort of a mini-brain to compare the on-board simulated virtual reality with the reality outside the vehicle due to activity of sensors, mini-brain control system and effectors. Such an on-line comparison may enable the achievement of expected functionality, performance and safety of the AU-AI-based vehicle for the benefit of a given mission.

1. GENERAL APPROACH TO AUV DESIGN

The following steps are usually conducted to achieve a basic set of characteristics of a successful AUV design[1]:

1. Define the design problem: design problem is defined as the AUV design and information on mission.
2. Determine the requirements: requirements concern the mission and vehicle.
3. Identify options for solutions: research into previous solutions to similar problems, brainstorming ideas for novel or improved approaches.
4. Examine tradeoffs & develop conceptual design(s): concept is a high-level design study of the major components within the design to determine

[1] AUVSI/ONR Engineering Primer Document for the Autonomous Underwater Vehicle (AUV) Team Competition. Association for Unmanned Vehicle Systems International (AUVSI), US Navy Office of Naval Research (ONR), Version 01 – July 2007

basic functionality; design steps may include: power components, navigational hardware, propulsion, basic hydrostatics and dynamics, major structural components, etc.; specifications are further developed using the spiral development process.

5. Perform cost analysis: cost analysis for the major components should be considered to determine the budget requirements; the project plan and timeline should be assessed.
6. Select concept option & design: the selected concept option should be matured through a final fabrication design; the design process is an iterative one, requiring give and take between the various disciplines; the design spiral process is followed allowing the team to evaluate decisions made along the way with respect to their effect on other design aspects.

2. APPROACH TO AUV DESIGN BASED ON PERFORMANCE-ORIENTED

RISK-BASED METHOD

The major features of AU-AI-based vehicles should be their functionality, performance and safety. The vehicle's functionality is closely connected with the application area the vehicle is designed for. The definition of functionality requires the missions and tasks in operation to be defined. The current paper concentrates on AU vehicles for the underwater activity (patrol, reconnaissance, combat tasks and missions). The best techniques to define the missions and tasks to be performed in operation are the entire event trees (FTA – Fault Tree Analysis, ETA – Event Tree Analysis, called the consequences). The event trees should be implemented by the operational officers for each mission and each task within the data mission. These event trees are the basis for prediction of the vehicle performance for each event separately.

According to the event trees defined above, the vehicle's performance can be predicted for each task of the entire event tree. The assessment of performance is connected with estimation of the AUV parameters, characteristics and features for each data event. Such an approach enables to check if the vehicle is able to perform any task defined for each mission. It seems to be a good method and tool for training purposes of AUV operators and for controlling the tasks during the data mission. Taking into account the event tree and assessment of performance defined above, it is possible to perform the qualitative and quantitative risk assessment (QQRA) of the AUV mission taking into account the risk of each event.

All the above steps create the performance-oriented risk-based method of the AUV design. This method can be used at the AUV design stage and during the AUV operation, as it is based on the same definition of event tree, assessment of vehicle's performance and risk assessment. The following steps are conducted

to achieve a basic set of parameters, characteristics and features of a successful AUV vehicle design when the performance-oriented risk-based method is applied[2]:

1. Define the AUV design functionality: define the missions, define the tasks within each mission, define the entire event tree for each mission and each task within the data mission.
2. Assessment of the AUV performance: estimation of parameters, characteristics and features for each event within the defined event tree (mission).
3. Qualitative and quantitative risk assessment based on the definition of event tree (mission) and assessment of AUV performance.

The research and design methodology is based on application of key advanced technologies which should provide the innovative solution to the final design of the AU-AI-based vehicle. Between those technologies, the major role is played by the following technologies:

– autonomous systems – has an impact on the AUV-AI-based vehicle design,
– sensors and effectors – has an impact,
– materials including the advanced composite materials – has an impact,
– innovative energy supply sources – has an impact,
– innovative propulsion systems – has an impact,
– IT technologies including the communication, navigation and controlling,
– stealth technologies – has an impact,
– space and satellite technologies – has an impact.

The above simply means and all the above technologies should be incorporated within the proposed AUV-AI-based design.

3. KEY DESIGN AND OPERATIONAL DRIVERS OF AU-AI-BASED VEHICLES

A basic set of design and operational parameters, characteristics and features which is necessary to control the AU-AI-based vehicle may be estimated during the assessment of performance using the algorithm presented in Table 1.

One between the major research objectives is to work out an AU-AI-based stealth vehicle which may possess a few features enabling to obtain a stealth-type performance of the vehicle. Between these features are:

– limited boundary layer and wake,
– limited emission of noise and vibration,
– other.

[2] M. Gerigk, Kompleksowa metoda oceny bezpieczeństwa statku w stanie uszkodzonym z uwzględnieniem analizy ryzyka (rozprawa habilitacyjna) – in Polish. A complex method for safety assessment of ships in damaged conditions using the risk assessment – in English, Wydawnictwo Politechniki Gdańskiej, Monografia 101, Gdańsk 2010.

Table. 1. An example of a basic set of design and operational parameters, characteristics and features necessary to control the AUV-AI-based vehicle[3].

Design stage	Description of design stage	AUV vehicle performance – features (F) – characteristics (CH) – parameters (P)
S1	Main aim, design objectives	F: good floatability, stability, resistance and propulsion, manoeuvrability, seakeeping CH: associated with the above features P: associated with the above features and characteristics
S2	AUV definition Environment definition	F: hull form Ch: buoyancy, displacement P: length, breadth, height P: sea state, depth
S3	AUV arrangement of internal spaces	F: subdivision Ch: capacity of compartments P: number of bulkheads
S4	Selection of structure materials	F: material, features of material Ch: AUV structure mass and weight, centre of gravity P: skin thickness, internal structure thickness
S5	Selection of equipment and on-board systems	F: distribution of mass and weights Ch: centre of gravity of each mass and weight P: position and mass of each mass and weight
S6	Estimation of mass and weight of AUV light vehicle	Ch: mass and weight of AUV light vehicle P: position of centre of gravity of AUV light vehicle
S7	Estimation of mass and weight of AUV vehicle for all the operational loading conditions including the internal loads	Ch: mass and weight of AUV vehicle for each loading condition P: position of centre of gravity of AUV vehicle for each loading condition
S8	AUV performance – statics	F: phenomena, floatability, stability, survivability Ch: buoyancy, displacement, righting arms, criteria P: draft, immersion, trim, angle of heel

[3] Research project No. PBS3/A6/27/2015 entitled: „Model obiektu wodnego typu stealth o innowacyjnych rozwiązaniach w zakresie kształtu, konstrukcji i materiałów decydujących o jego trudno-wykrywalności" - in Polish. "A model of waterborne stealth-type object of innovative solutions concerning the hull form, structure and materials having an impact on the object stealth characteristics" - in English. Project conducted at the Gdańsk University of Technology between 2015 and 2018 and founded by the National Centre for Research and Development NCBiR within the PBS III initiative.

Design stage	Description of design stage	AUV vehicle performance – features (F) – characteristics (CH) – parameters (P)
S9	AUV performance – dynamics	F: phenomena, resistance and propulsion Ch: resistance curve, demanded and operational power curves, propeller thrust curves, resistance-based hydrodynamic forces, propeller-based hydrodynamic forces, criteria P: AUV speed, number of propellers F: phenomena, manoeuvrability Ch: course keeping, turning, criteria P: diameter of circulation curve, zig-zag type dynamics F: phenomena, seakeeping Ch: degrees of freedom, equations of motion, amplitudes of linear and angular characteristics of motion, velocities and accelerations, criteria

The stealth technology is defined as: minimizing the probability of detection of the S-AUV using the well known and „unknown" means (technologies, devices, etc.). The "stealth" function is anticipated as follows:

$$E = E\,[p_1, p_2,..., p_n, f_1(x_1, x_2,..., x_{m1}), f_2(x_1, x_2,..., x_{m2}), ..., f_k(x_1, x_2,..., x_{mt})] \quad (1)$$

where: k – No. of a stealth technology applied; m_1, m_2, m_3, m_4, m_5, m_6, m_t – No. of independent (dependent) characteristics for the data stealth technology; p – parameters; x - variables; f – a stealth characteristics (function, polynomial, etc). The physical fields for the research have been anticipated as follows: F1 – main particulars, hull form (geometry), F2 – skin covers (nano-surface) – materials; F3 – noise and vibrations; F4 – electromagnetic, magnetic; F5 – thermal (heating); F6 – boundary layer and wake; F - visibility. The first step during the research was to check how much a hull skin cover may affect the AU-AI-based vehicle flow including the boundary layer and wake. During the computer simulation of the flow the mesh consisting of 3 275 000 elements was used. The numerical domain had the size[4]: 5 meters x 1.5 meters x 1.2 meters. The water flow velocity was anticipated to be from 0.5 up to 2.5 meters per second with the step 0.5 meters per second. During the simulation the hull skin cover was generated by the skin roughness as follows:

- Ra 80 – as a normal steel plate surface,
- Ra 1.25 – as a slightly polished steel plate surface,
- Ra 0.01 – as a polished steel plate surface,
- Ra 0.0025 – extremely polished steel plate surface (so-called nano-surface).

[4] D. Kardaś, P. Tiutiurski, M. Gerigk, Internal report of the Gdańsk University of Technology: "Modelowanie opływu obiektu OWS. Model warstwy przyściennej". Opracowanie nr 1/IMP, Projekt PBS3/A6/27/2017, Politechnika Gdańska, Gdańsk 2016.

The flow was estimated for the distance 0.5 meters, 1.0 meters, 1.5 meters and 2.0 meters behind the AU-stealth vehicle. The second step during the research was to check the influence of the parameters (modelled roughness, nano-surface) of the hull skin cover on the flow including mainly the boundary layer. During the computer simulation three types of nano-surface has been modelled. Some results of the computer simulation of the flow estimation in the boundary layer (for the data skin roughness, for the nano-surface modelled)[5]. The third step was to check the influence of the hull skin cover on the sonar system signal. During the towing tank investigations three types of AUV-Stealth hull skin covers were tested[6].

The above mentioned information shows the level of research associated with prediction of some performance features, characteristics and parameters, which have an impact on the AU-AI-based vehicle performance in operation. It is necessary to underline that prediction of the set of design and operational parameters, characteristics and features, which is necessary to control the AUV-AI-based vehicle presented in Table 1, should be followed by an algorithm for prediction of the so-called AUV control power, presented in Table 2.

Based on the above mentioned algorithms, it is possible to predict the necessary level of autonomy to be achieved due to the AUV performance data. The level of autonomy from null up to two may concern a vehicle which is a kind of an automated robot performing programmed tasks. Levels from three up to five refer to the AUV vehicles which posses more advanced solutions concerning the sensor, control and effector systems. The most advanced solution, the level five of autonomy, is a case when the vehicle has an on-board mini-brain which enables to compare the current situation outside the vehicle (reality) using the sensors with the virtual reality stored and simulated within the vehicle's mini--brain.

Nonetheless, construction of an AU-AI-based vehicle does not mean merely equipping it with a steering system consisting of the sophisticated hardware and AI-based software. On the contrary, it requires the achievement of an innovative hull form which should be capable of diving. If the AUV performance is very good, the sensors, control and effectors driven by the AUV mini-brain guarantee the highest level of functionality, performance and safety. It is highly probable in such a setting that all the tasks within the mission will be performed satisfying the mission requirements. The innovative hull form, arrangement of internal spaces, materials used for the vehicle's structure, distribution of equipment and on-board

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[5] E. Ciba, P. Dymarsk, M.K. Gerig, Internal report of the Gdańsk University of Technology: "Modelowanie opływu obiektu OWS. Model pokrycia nano. Model warstwy przyściennej". Opracowanie nr 1/PG/WM, Projekt PBS3/A6/27/2017, Politechnika Gdańska, Gdańsk 2018.

[6] F. Barański, M.K. Gerigk, Internal report of the Gdańsk University of Technology: "Badania hydroakustyczne modelu obiektu AUV-Stealth". Opracowanie nr 1/PG/KFB, Projekt PBS3/A6/27/2017, Politechnika Gdańska, Gdańsk 2018.

Table. 2. An example of a basic set of design and operational parameters, characteristics and features necessary to predict the AUV-AI-based vehicle control power.

Design stage	Description of design stage	AUV vehicle performance – features (F) – characteristics (CH) – parameters (P)
S10	Estimation of demanded power necessary to run the sensor systems	F: sensor systems control power CH: demanded power by the pressure measuring system, hydroacoustic system (sonar, echo sound, hydro phone), thermovision system, electromagnetic system P: data signals in time domain, current intensity, voltage of the current
S11	Estimation of demanded power necessary to run the IT deck-steering, navigation and communication systems	F: deck-steering, navigation, communication systems control power CH: demanded power by each system depending on the time of work P: data signals in time domain, current intensity, voltage of the current
S12	Estimation of demanded power necessary to run the effector systems	F: effector (manipulator, dedicated) systems control power CH: demanded power by each system depending on the time of work P: data signals in time domain, current intensity, voltage of the current
S13	Estimation of demanded power necessary to run the mini-brain control system	F: mini-brain control system power CH: demanded power by the mini-brain control system depending on the time of work (on-line system) P: data signals in time domain, current intensity, voltage of the current
S14	Estimation of demanded power of batteries necessary to run the propulsion and remaining on-board systems	F: demanded power used by propulsion system, demanded power used by the remaining systems CH: demanded power characteristics depending on the time of work (on-line system) P: data signals in time domain, current intensity, voltage of the current

systems all contribute to the optimal position of the vehicle's centre of gravity and impact the operation of the global hydrodynamic force in each period of time. Also the internal and external loads on the AUV's structure have an impact on the amount of energy used during operation, with major influence of the vehicles' resistance force. This force depends on the vehicle's speed and is decisive for the maximum range of the AU-AI-based vehicle. The vehicle's hull form and propulsion system have a big impact both on the vehicle's speed and range, hence it is necessary to apply the most innovative solutions from the design and performan-

ce point of view. The entire capacity of the energy supply source should be increased due to energy necessary to supply the work of the sensors, mini-brain control and effectors systems. The mini-brain control system coordinates the distribution of energy and information for all on-board systems and AU-AI--based vehicle itself. Taking into account navy applications, it is necessary to deliver a limited boundary layer and wake, limited emission of noise and vibration, as well as other factors. They may enable the AU-AI-based vehicle to remain difficult to be detected, but at the same time to better detect obstacle and enemies, and thus better prepared to perform the mission.

4. KEY SOLUTIONS. A CONCEPT OF MINI-BRAIN CONTROL SYSTEM. PRELIMINARY RESULTS OF OWN AU-AI-BASED VEHICLE DESIGN

Conceptualizing and elaborating autonomous AU-AI-based vehicles requires replacement of two or three dimensional work concepts with concepts based on the space of operation. Within the space of operation, humans will be supported and sometimes replaced by Artificial Intelligence (AI). Information will be exchanged on-line between all the linked systems that have been granted access[7] and the exchange of data in real time domain should be permanent. The complex air-based systems require speed of data transfer at the level of 500 Mb/s, which means that the unmanned autonomous underwater systems like the AU-AI-based vehicles should rather be a system of systems. It is necessary to apply such an approach if the future AU-AI-based vehicles are to be functional, exhibit good performance and remain safe in the space of operation.

The sensor system and AI-based mini-brain control system decide about the AU-AI-based vehicle senses. Visual, pressure, electromagnetic and hydroacoustic signals are processed by the AI-based mini-brain control system. This system works as an Inference Engine combining the Forward and Backward Chaining algorithms[8]. Such an approach makes possible comparison of the AUV-AI-based mask (virtual reality) with reality as described by the sensor systems. Preliminary results of research have shown that it is possible to let the AUV-AI-based vehicle to be an intelligent vehicle if the functional, performance, operational (mission, tasks) and safety standards, limitations and criteria are controlled the AI-based mini-brain control system. The methodology of work of the AI-based mini-brain control system is built according to the following main steps:

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[7] T.J. Sejnowski, Deep learning, Głęboka Rewolucja, Kiedy sztuczna inteligencja spotka się z ludzką. Wydawnictwo Poltext (Tłumaczenie). © 2018 Massachusetts Institute of Technology. ISBN 978-83-7561-962-1.

[8] Ch. F. Chabris, A primer of artificial intelligence. © Multiscience Press Inc. 1987, 1988. ISBN 1-85091-698-5.

- setting the requirements,
- defining the AU-AI-based vehicle operational conditions (defined mission and tasks, mission route, key points of mission route, energy supply source state, autonomy state: time and range, control points, coded communication),
- identifying the operational hazards and event scenarios during the mission,
- assessing the AUV-AI-based vehicle performance during the mission,
- estimating, assessing and managing the mission risk,
- making the decisions on safety,
- selecting the best operational solutions that meet the mission requirements,
- optimizing the mission.

Constructing an intelligent AI-based AUV does not mean to equip the vehicle with a control system consisting of advanced hardware and AI-based software. Intelligent AU-AI-based vehicle requires the use of innovative hardware (novel hull form, innovative solutions concerning the sensors, etc.) and software which help to satisfy the functional, performance and safety requirements during a mission in an "intelligent way". From the practical point of view, it means that the AUV-AI-based vehicle is able to better detect underwater reality, including obstacles, in order to better perform the dedicated tasks and to complete the entire mission successfully.

The key solution concerning the control system. Sensor systems and AI-based control system combined together decide about the AU-AI-based vehicle senses. The visual, pressure, thermal, electromagnetic and hydroacoustic signals are processed by the AI-based mini-brain control system. This system works as a kind of Inference Engine combining the algorithms:

- Forward and
- Backward Chaining.

Such an approach enables to compare the AUV-AI-based Mask (virtual reality) with the reality being described by the components of sensor systems. The major components of the AUV-AI-based and AUV-AI-based Mask systems are presented in Figure 1. The first step of investigations on the development of the AU-AI-based vehicle equipped with some elements of the AI-based mini-brain control system has been done. There is a growing hope that the dedicated AU-AI-based vehicle would successfully reach the second step of the R&D investigations where the manoeuvres presented in Figure 2 will be performed in the real operational conditions.

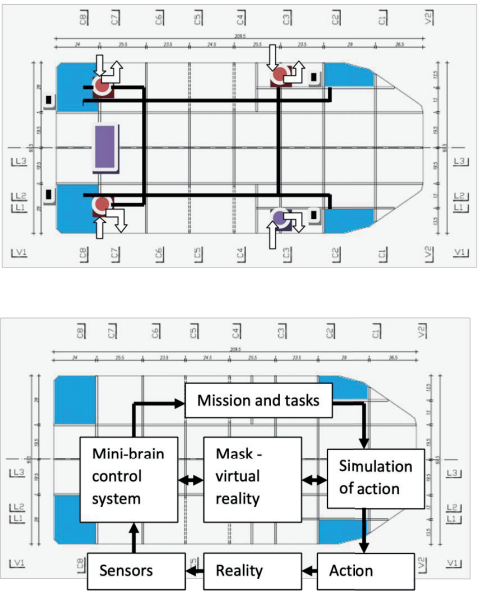

Figure 1. Some elements of the AUV-AI-based control system including the ballast system and elements of the AUV-AI-based Mask systems.

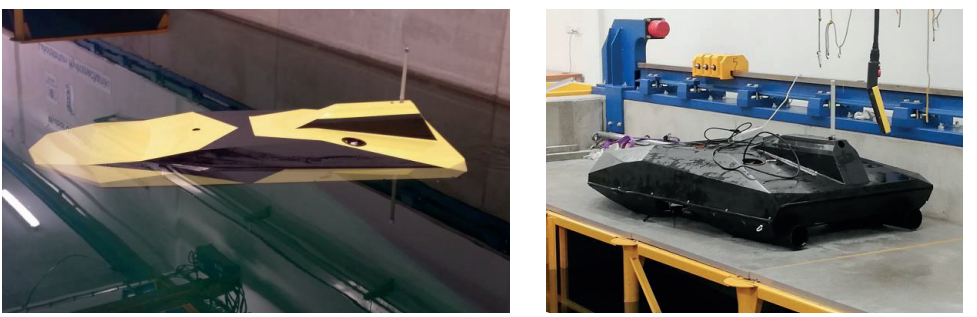

Figure 2. An advanced AUV-AI-based demonstrator during the towing tank test.

5. CONCLUSIONS

The last decade has been devoted to further development of the UUVs, or unmanned underwater vehicles, and AUVs – autonomous underwater vehicles. There is a growing interest to obtain successful implementations of a fully autonomous underwater vehicle[9]. The main drivers for further development of AUVs

[9] M. K. Gerigk, Modelling of combined phenomena affecting an AUV stealth vehicle. TRANSNAV the International Journal on Marine Navigation and Safety of Sea Transportation, Volume 10, Number 4, December 2016 (druk: 2017), DOI: 10.12716/1001.10.04.18.

are the following technologies: autonomous systems, sensors and effectors, materials, energy supply sources, propulsion systems, IT technologies and stealth technologies. There is a growing necessity for fast development of IT technologies including the combined control, navigation, communication, sensor and effector systems for underwater applications. Such developments may bring to life a vision of fully autonomous AUVs. It is possible to let the AU-AI-based vehicle to be an intelligent vehicle if the functional, performance, operational (mission, tasks) and safety standards, limitations and criteria are supervised by the AI-based mini--brain control system[10].

The AUV-AI-based vehicle concept has been worked out where the combined sensor and AI-based control systems enable to compare the reality and on--board virtual reality in operation. According to this concept, basic functional, performance, operational and safety features, characteristics and parameters of the AU-AI-based vehicle have been investigated. Obtaining an intelligent AU--AI-based vehicle does not mean to equip her with:

– steering system consisting of the advanced hardware and
– AI-based software.

The intelligent AUV-AI vehicle requires an innovative hardware and software (hull form, etc.) which all together contribute to the fact that an AU-AI vehicle is keen on behaving (diving, etc.) in an "intelligent way"[11].

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[10] M. Gerigk, Wielokryterialne projektowanie budynków wielofunkcyjnych ze szczególnym uwzględnieniem kryterium elastyczności funkcjonalnej, Gdańsk 2018, pp. 1-142. See also: M. Gerigk, Multi-Criteria Approach in Multifunctional Building Design Process, Gdańsk 2018, pp. 1-8 and 245. https://doi.org/10.1088/1757-899x/245/5/052085.

[11] M.K. Gerigk, Modeling of performance of an AUV stealth vehicle. Design for operation. Proceedings of IMAM 2017, 17th International Congress of the International Maritime Association of the Mediterranean, Lisbon, Portugal, 9-11 October 2017. Volume 1, @ 2018 Taylor Francis Group, London. A Balkema Book, ISBN 978-0-8153-7993-5, pp. 365-369.

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SATBAŁTYK SYSTEM – SATELLITES FOR THE SAFETY OF THE BALTIC SEA

Abstract: The *SatBałtyk system* is a satellite-based platform for monitoring the Baltic Sea environment in near real-time. Since 2015, it has been providing reliable information supporting the protection and management of the ecosystem and marine resources. Such information is of a wide range of applications including many safety-related, not always obvious. Some of them were briefly presented in the paper. Providing valuable support in threats prevention, rescue operations and decision-making processes, the *SatBałtyk System* can be of great importance for improving the safety of people, the environment and infrastructure related to the sea.

Keywords: *SatBałtyk System*, Satellite monitoring of the Baltic Sea, Remote sensing, Protecting and management of the marine environment, Safety of offshore infrastructure

INTRODUCTION

The exploration and exploitation of the seas and oceans by humans has a long history and star observation has always been an invaluable help in this. For a long time in the past, stars were the sailor's close friends. The only possibility to reach the destination and return home safely was celestial navigation. Today, the development of knowledge and technology allows us to send satellites – our new stars with a wide range of sensors – into orbits around the Earth. Such new stars send explorers the information they need in order to reach their destination safely and fast (efficiently), and it must be borne in mind that the role of the sea in our everyday life and economy has increased. The usage of satellite observation in the exploitation of seas and oceans begins in the 1970s. It has been a relatively short

time since then, but satellites systematically monitor large areas and they are an ideal platform for observing the seas and oceans. It is safe to say, that the surge in application of space technologies started a new era in many areas of human activity related to the sea.

The development of technology makes it possible to place on board advanced sensors recording with high resolution subtle changes of various characteristics describing phenomena occurring in the surface layer of the seas. The operators of publicly funded satellite missions undertake a number of activities to facilitate the access and interpretation of satellite data. Among the possibilities of using satellite techniques the most important are associated with broadly understood safety issues. Safe navigation, rescue missions saving human life, safety of offshore investments, are all very important and topical issues. But the most important for our future is the safety of the seas and oceans themselves. The seas are used more and more intensively. More and more people inhabit coastal areas, the industry is developing and infrastructure is being built, industrial and agricultural pollution flows down the rivers. Marine ecosystems are functioning under increasing pressure from human activity. In the long term, this could degrade the marine environment and, consequently, adversely affect living conditions throughout the biosphere. If we want to ensure safety for the next generations, we must focus on ecological safety of the seas and oceans. This is particularly evident in coastal regions and inland seas where changes caused by anthropological impact are the fastest.

THE *SATBAŁTYK SYSTEM*

An example of such an ecosystem, changing under the influence of various factors related to the development of civilization, is the Baltic Sea, surrounded by countries with highly developed industry and agriculture. Reliable impact assessment of these human activities requires deep knowledge of the processes taking place in the sea and appropriate tools to track changes in it. A good example of such a modern and innovative tool is the *SatBałtyk System*.

The *SatBałtyk System* is a satellite-based platform for monitoring the Baltic Sea in various time and spatial scales. It was launched in 2015 under the European Funds (Innovative Economy Program) as a response from the scientific community to the growing demand for access to reliable and up-to-date information on the Baltic Sea environment. The scientific foundations of the *SatBałtyk System* have been developed as a result of many years of cooperation of a large group of scientists from the institutions associated with the SatBałtyk Scientific Consortium[1]. This team of experienced scientists used the knowledge accumula-

[1] Scientific Consortium SatBałtyk with leading role of IO PAN was founded in 2010 by Institute of Oceanology Polish Academy of Sciences (IO PAN), Gdańsk University (UG), Szczecin

ted over the years about the processes taking place in the Baltic Sea environment combined with many years of analysis of the relationships between the optical properties of waters and the content of substances that shape these properties, as well as many innovative proprietary solutions and advanced research methods. Suffice it to say, that work on the development of the algorithms used in the *SatBałtyk System* has been going on in Poland for the last 20 or even 30 years[2].

These studies were based on traditional research methods. They include measurements of many hydrological, optical, biological and geo-chemical parameters carried out directly in the water and laboratory analyzes of research material in collected samples. Naturally, the data collected in this way mainly describe a small section of the sea surface limited to the area and time in which the measurements were conducted. Analyses of such data must take into account the inaccuracies associated with the natural variability of the marine environment at different time and spatial scales. There is no doubt that satellite observations that can cover large sea area in a single instant could be a perfect tool to study the marine environment. But it is also indisputable that the quality of this data largely depends on proper verification. The main assumption during the development of the system of satellite monitoring of the Baltic Sea environment was that it can only be reliable and credible if it uses multiple sources of information. Figure 1 shows schematically the main elements of the complex infrastructure of the *SatBałtyk System* and the data sources, based on which the characteristics describing the Baltic Sea ecosystem are determined.

To ensure the accuracy and credibility of provided parameters a very complex information flow system has been organized. The satellite data are used for the day-to-day monitoring of large sea areas. Simultaneously, an important role is played by *in situ* measurements from continuous monitoring systems (buoys, fixed platforms, shore stations and others) and research vessels. At the stage of developing the *SatBałtyk System*, *in situ* data was necessary to develop models and algorithms for the determination of actual physical, chemical and biological characteristics of seawater from satellite data; now they are mainly used to validate and verify the accuracy of the environmental characteristics provided by the *SatBałtyk System*. Last but not least, the system contributed to the advancement

University (US) and Pomeranian Academy in Słupsk (APS) for developed and launched a system of a near real-time monitoring of the Baltic Sea environment within the project funded by the European Union through European Regional Development Fund, (contract No. POIG.01.01.02-22-011/09.

[2] For more details see: B. Woźniak, A. Krężel, M. Darecki, S.B. Woźniak, R. Majchrowski, M. Ostrowska, Ł. Kozłowski, D. Ficek, J. Olszewski, J. Dera, Algorithm for the remote sensing of the Baltic ecosystem (DESAMBEM). Part 1: Mathematical apparatus. Oceanologia 50 (4) 2008, pp. 451–508; M. Darecki, D. Ficek, A. Krężel, M. Ostrowska, R. Majchrowski, S.B. Woźniak, K. Bradtke, J. Dera, B. Woźniak, Algorithms for the remote sensing of the Baltic ecosystem (DESAMBEM). Part 2: Empirical validation. Oceanologia 50(4) 2008, pp. 509–538, and the works cited therein.

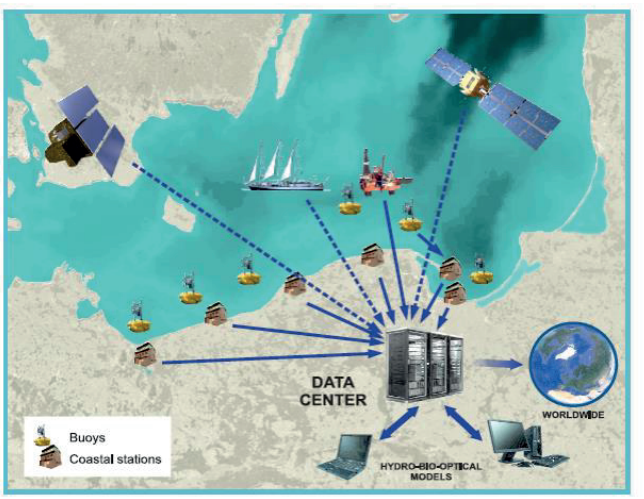

Figure 1. Scheme of the *SatBałtyk System* infrastructure

of knowledge, as a result of which new algorithms are still being developed by the team of researchers from institutions within the Consortium.

Another important element of the *SatBałtyk System* infrastructure is a set of hydrodynamic and eco hydrodynamic prognostic models based on the physical and biochemical principles governing the spatial distributions of the relevant parameters. Models included in the set have been expanded or modified during the *SatBałtyk System* development. Their main task is to reconstruct the satellite data when, due to cloud cover, such data couldn't be provided from optical and infrared satellite sensors. The geographical location of the Baltic Sea, frequent cloud cover, specific properties of the Baltic atmosphere and, above all, complex optical properties of its waters, mean that the operational use of satellite remote sensing in the monitoring of the Baltic Sea environment, encounters additional barriers compared to most of the other basins Many applications require constant and reliable monitoring of the sea, and for them any interruptions in the stream of satellite information can be considered as a serious weakness of the system providing data for them. Developed advanced and innovative methodology of merging the satellite and modelled data allows delivering a live and uninterrupted assessment of the current state of the Baltic Sea environment, even when satellite data acquisition could not be performed[3].

The solutions used in the *SatBałtyk System* enable providing in the website http://www.satbaltyk.pl comprehensive, precise and high-quality data describing the Baltic Sea environment. All the parameters are available in the form of maps

[3] These methods are described in detail in M. Konik, M. Kowalewski, K Bradtke, M. Darecki, The operational method of filling information gaps in satellite imagery using numerical models, Int. J. Appl. Earth Obs. Geoinformation, (75) 2019, pp. 68-82, https://doi.org/10.1016/j.jag.2018.09.002

presenting their spatial variability over the entire Baltic or in its selected area (see Fig. 2). System already provides information covering the last 20 years, and this period will still be expended. All parameters are divided into eight categories: 1. Atmosphere, meteorology (e.g. air temperature, atmospheric pressure, cloudiness, wind speed and direction, distribution of solar radiation at the sea surface), 2. Hydrology (e.g. temperature and salinity of the water at different depths, the dynamic state of the sea surface, sea level), 3. Ocean optics (e.g. concentrations of optically active seawater constituents and their absorption coefficients of solar radiation), 4. Radiation budget (e.g. downward and upward flows and doses of long- and short-wave solar radiation, sensible and latent heat), 5. Sea water components (e.g. phytoplankton biomass, the concentration of phytoplankton pigments at different depths in the sea), 6. Phytoplankton, photosynthesis (e.g. spectral distribution of photosynthetically active radiation and energy absorbed by phytoplankton, vertical distribution of the yield of photosynthesis and rate of primary production), 7. Coastal zone (e.g. width of the dry beach, range of beach inundation), 8. Hazards (historical data). What is important, the spatial distributions of these parameters are available to users at different depths, and if necessary, also for different wavelengths of visible light in near real-time. Apart from the common oceanographic parameters of the marine environment, the system determines also advanced parameters, describing a more complex natural processes and characteristics. Many of these characteristics are unique, and their values are not determined operationally by any other comparable system[4]. It enables not only to track long-term changes in the marine environment but also to comprehensively analyze processes taking place in Baltic ecosystems, such as:

- The influx and distribution of the solar radiation energy consumed during various processes in the atmosphere-sea system;
- The radiation balance of the sea surface;
- The optical conditions in which photosynthesis of organic matter takes place and the condition of marine plant communities;
- Distributions of sea surface temperature (SST) and the links between this temperature and various phenomena occurring in the sea;
- Hazards and effects due to storm states in the coastal zone of the sea.

[4] More detailed information on the *SatBałtyk System* is contained in the following works: B. Woźniak, K. Bradtke, M. Darecki, J. Dera, J. Dudzińska-Nowak, L. Dzierzbicka, D. Ficek, K. Furmańczyk, M. Kowalewski, A. Krężel, R. Majchrowski, M. Ostrowska, M. Paszkuta, J. Stoń-Egiert, M. Stramska, T. Zapadka, SatBaltic – A Baltic environmental satellite remote sensing system – an ongoing Project in Poland. Part 2: Practical applicability and preliminary results. Oceanologia 53(4) 2011, pp. 925–958, doi:10.5697/oc.53-4.925; B. Woźniak, K. Bradtke, M. Darecki, J. Dera, L. Dzierzbicka, D. Ficek, K. Furmańczyk, M. Kowalewski, A. Krężel, R. Majchrowski, M. Ostrowska, M. Paszkuta, J. Stoń-Egiert, M. Stramska, T. Zapadka, T., SatBaltic – A Baltic environmental satellite remote sensing system – an ongoing Project in Poland. Part 1: Assumptions, scope and operating range. Oceanologia 53(4) 2011, pp. 897–924. and in the works cited therein

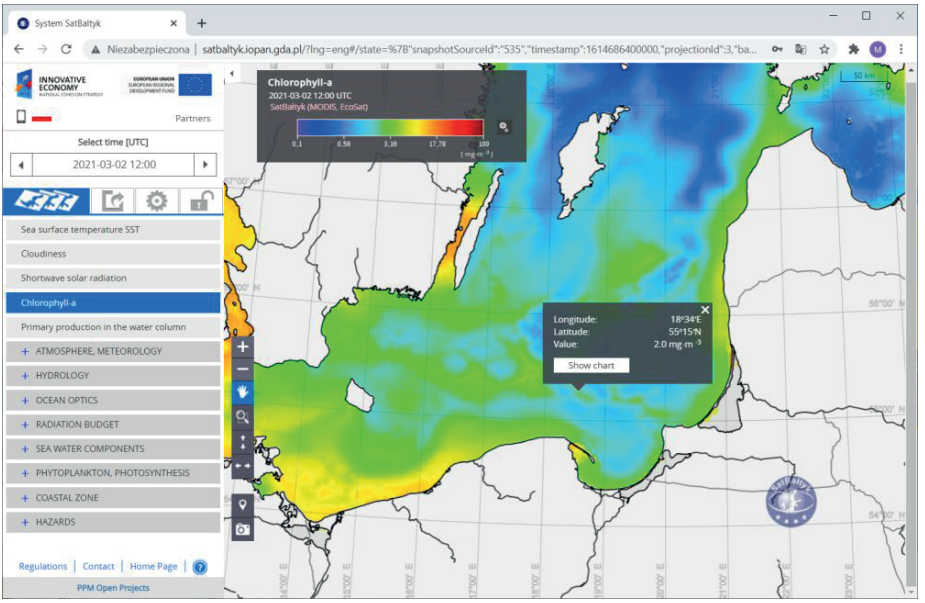

Figure 2. An exemplary map of the distribution of chlorophyll values in a selected area of the Baltic Sea. For each point on the map, you can also read the exact values of the selected parameter. (source: www.satbaltyk.pl).

SAFETY

The holistic information provided by the *SatBałtyk System* describes a sea--coast-atmosphere system as a whole, including, what is important and unique, vertical and spectral variability of physical, chemical and biological parameters. Such information can be essential for protection and management of the marine environment, in particular for the assessment of safety, condition, transformations and the functioning of the Baltic ecosystem, as well as the safety of various aspects of human activity in this environment.

For many years, the Baltic ecosystem has been struggling with eutrophication. It is excessive growth of algae due to the increased availability of nutrients deposited from the many land sources. Due to the progressive eutrophication and many other phenomena indicating the degradation of the Baltic environment, agreements were concluded at the international level to prevent this threat. To restore the Baltic to conditions unaffected by eutrophication by 2021, the Helsinki Commission (HELCOM) issued its Baltic Sea Action Plan (BSAP) in 2007, by which the countries around the Baltic Sea committed themselves to reduce emissions of compounds causing eutrophication[5]. The effects of the im-

[5] Baltic Marine Environment Protection Commission, Baltic Sea Environment Proceedings No. 143, Eutrophication Status of the Baltic Sea 2007-2011, A concise thematic Assessment, HELCOM, Helsinki 2014, p. 7 et seq.

plementation of the Plan are assessed based on multi-faceted analyses of a set of several different environmental parameters. One of the commonly used core indicators of the condition of the marine environment is the average chlorophyll-a concentration in the surface water (0 – 10 m) during summer (June – September) annually determined based on *in situ* measurements. This makes it possible to include in the analysis the maximum of this concentration at depth, where the two main limiting factors – the intensity of solar radiation penetrating the water column and the concentration of nutrients in the water – create optimal conditions for photosynthesis. Usually, satellite data can provide information only about the parameters related to the surface of the water. However, thanks to the algorithm used for approximating the vertical distributions of total chlorophyll which took into consideration the principal features of these distributions, specific to the Baltic waters, not only values but also the temporal evolution of the core indicator can be easily calculated and provided from the *SatBałtyk System* (Fig. 3).

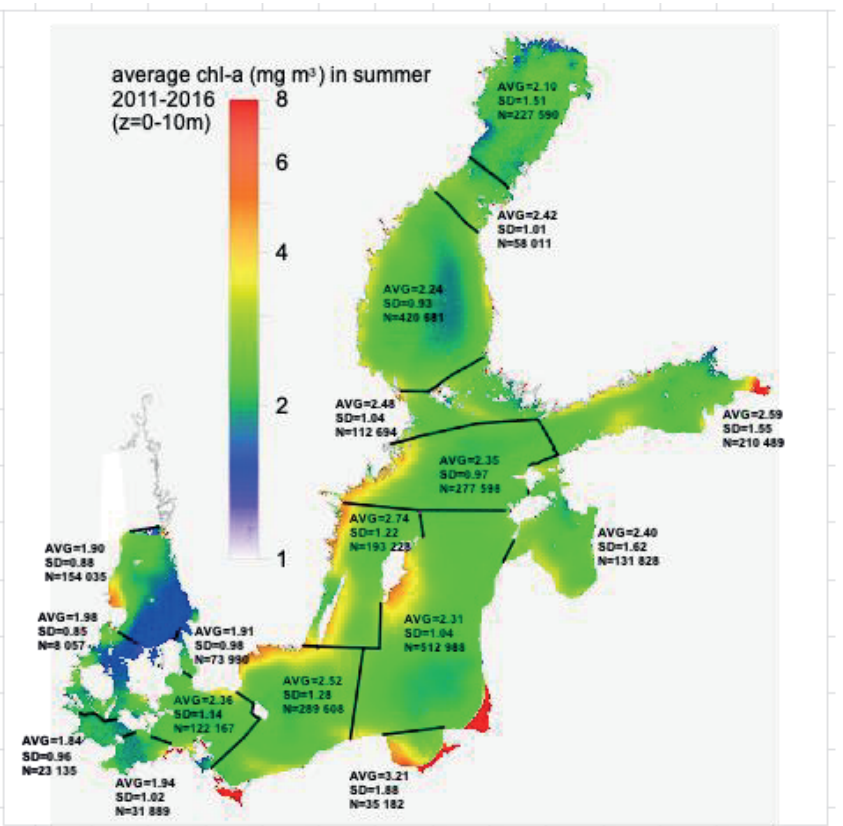

Figure 3. The averaged over the layer 0-10m chlorophyll a concentration for the summer (June – September) in years 2011-2016. The map presents mean values, standard deviations determined based on data from the *SatBałtyk System* for regions used by HELCOM.

At the same time, without a doubt, the values obtained on the basis of daily, verified information available in the *SatBałtyk System,* reflect the variability of the environmental condition of the Baltic Sea much better than single-point measurements. The *SatBałtyk System* also offers information on the development of algae as a result of eutrophication. The analysis of data of primary production enables fast assessment of changes in the last decade without involving significant resources in measurement campaigns. An example of such an assessment is in Figure 4, presenting the annual values of primary production averaged for the entire Baltic Sea for the decade 2010-2019.

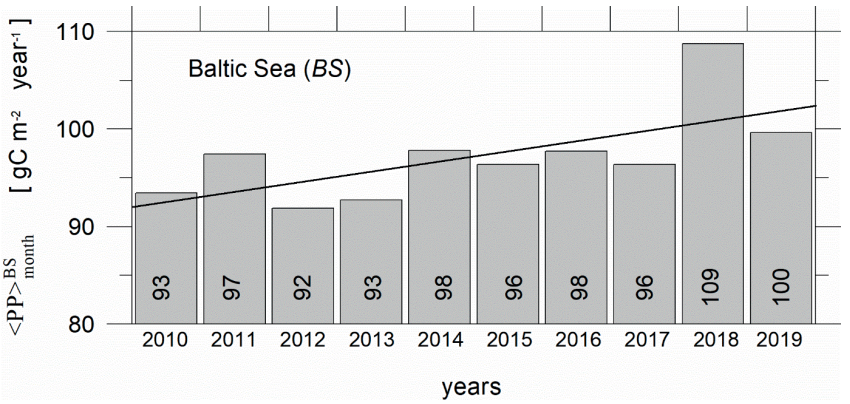

Figure 4. The total yearly primary production and the trend line for the entire Baltic Sea determined using data from the *SatBałtyk System.*

Supporting environmental protection is an obvious task performed by the *SatBałtyk System*. However, this is not the only possibility of using its resources in the context of security. Another issue – human safety and security of various human activities in the marine environment can equally well be assisted by information from the System. In rescue operations, during the search for survivors, information about the direction and speed of movement of objects in the water is extremely important. Owing to the use of hydrodynamic models, in the *SatBałtyk System*, current information and short-term forecasts of the direction of sea currents and waves are available and can be applied. They can prove to be a valuable support for rescue services in situations where time is decisive for the success of a mission. On the other hand, the analysis of historical data provided in the *SatBałtyk System* can significantly increase the probability of planned rescue scenarios in the areas covered by the surveillance and enables the prevention of dangerous events. One such example is the analysis presented in Fig. 5. It shows spatial variability of sea currents in the Polish coastal zone within the period 2011-2016.

Knowledge of the most common directions, average speeds of currents and their stability in this area is important for many safety-related areas. This applies

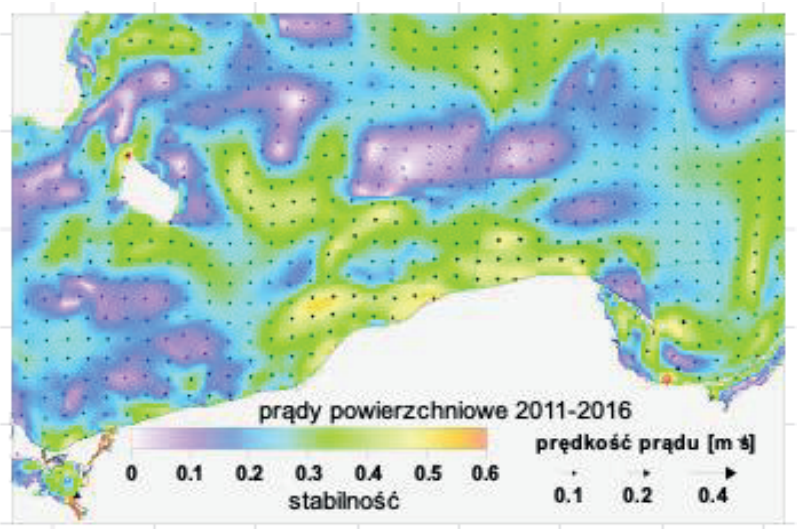

Figure 5. The spatial variability of mean sea current speed and sea current stability at a surface in the area of Polish coastal waters within the period 2011-2016 determined using data from the *SatBałtyk System*.

not only to saving human lives. Preventing and limiting the effects of various types of environmental threats that may affect health and safety of inhabitants of coastal regions or security of investments in coastal areas requires that this type of information be considered already at the planning stage.

All this information is made available without any restrictions to any entity interested in using it. Easy access and relatively low cost of data acquisition make satellite data more and more commonly used for various purposes, providing valuable support also in decision-making processes. The number of professional applications of information obtained from satellites is systematically increasing. However, this often requires the introduction of appropriate legal regulations also at the international level, recognizing information obtained from satellite data as a fully acceptable source of information about the marine environment, in many cases even equivalent to data obtained by classical, *in situ* methods. This aspect still requires a lot of activity and initiatives, especially at the national level. When considering satellite data as a source of reliable and useful information in applications related to various security issues, this data should be easily and safely available. That aspect seems to be already more or less solved, and nowadays, many user-oriented systems guarantee such constant access to appropriate and reliable satellite information, among them the Copernicus Marine Environment Monitoring Service (CMEMS) at European level and the *SatBałtyk System*, as a regional solution. This should not be overlooked when discussing the use of satellite techniques in any activities related to various security aspects.

In the case of oceanographic data, growing awareness of the benefits of using data from various sources results in activities that enable the development and

deployment of infrastructure for data management and the provision of FAIR[6] and open access to oceanographic data resources. This is not a trivial problem, it includes secure data storage, its proper description and professional access systems. Polish organizations engaged in research and exploitation of marine resources have been involved in activities targeting harmonization, integration and coordinated provisioning of environmental data resources for many years. In 2018, two consortia gathering most of the organizations involved in marine research and continuous acquisition of oceanographic data: POLMAR[7] and the Scientific Consortium SatBałtyk, both led by IO PAN, joined forces as the eCUDO[8] partnership to organize and deploy the system delivering demanded oceanographic data and products to the users. Deployment of a unified system providing access to data resources managed by key scientific organizations in Poland will give added value for the national economy through the increase of data availability for all stakeholders, with a concurrent decrease of the total cost of data acquisition, management and exchange. The system is open for all stakeholders and ready to aggregate other organizations and data sources, with view to solving the most pressing problem of discovery of all available sources of data, their harmonization, and ensure their safe storage and distribution.

SUMMARY

Easily accessible, verified and up-to-date information is the basis for the effectiveness of all activities not only related to safety. The possibilities of using the *SatBałtyk System* described in a nutshell do not exhaust the possible applications of satellite techniques to increase the safety of people, the environment and infrastructure related to the sea. It is extremely important and strengthening the position of Poland on the international arena, that the Polish science contributes to the construction of an economy based on knowledge and sustainable development, the main feature of which should be an ecosystem-based approach

[6] FAIR data are data which meet principles of Findability, Accessibility, Interoperability, and Reusability. The acronym and principles were defined in Wilkinson, M., Dumontier, M., Aalbersberg, I. *et al.* The FAIR Guiding Principles for scientific data management and stewardship. *Sci Data* 3, 160018 (2016). https://doi.org/10.1038/sdata.2016.18

[7] POLMAR Scienitific Consortium– with leading role of IO PAN was founded in 2012 by Institute of Oceanology Polish Academy of Sciences (IO PAN), Institute of Meteorology and Water Management National Research Institute (IMGW), Maritime Institute in Gdańsk (IMG), Polish Geological Institute National Research Institute (PIG PIB), National Marine Fisheries Research Institute (MIR PIB) and University of Technology in Gdańsk (PG).

[8] „Elektroniczne Centrum Udostępniania Danych Oceanograficznych eCUDO.pl" (eng. Oceanographic Data and Information System – ODIS) is a Project No POPC.02.03.01-00-0062/18-00 funded within the frame of Operational Programme Digital Poland for 2014-2020, managed by Digital Poland Project Centre (CPPC) with allocated budget 3.5M EUR (84,63% –ERDF, 15,37% national budget).

to the management of living resources and the values of the marine environment. It is high time to use the possibilities offered by satellite techniques not only for scientific research but also for safe exploitation of the Baltic Sea resources, ongoing assessment of the state of its environment and assessment of the effects of undertaken remedial actions. Further development of these applications is only limited by creativity and legal regulations. It is hoped that the legal and administrative regulations will keep pace with the possibilities of wide application of satellite techniques, also in wider security aspects.

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MANAGING THE INTERNATIONAL SPACE – THE BIG CHALLENGE AHEAD

Abstract: This paper deliberates on the kind of challenges the international space business might have and what actions should the states undertake to help operators to access to space. This is a qualitative research paper. The entire material included in this article comes from dedicated conferences and seminars about space business and policy organized, legal documentation, and literature review, which refer to business security or safety in this subject. The analysis conducted by authors shows that states are forced to take internal actions, to monitor and control private activities of entrepreneurs. Interaction of international and national legislation is necessary for the face of privatization of space activities (in the domain, such as liability and jurisdiction). States have the legislative mechanisms needed to establish a licensing and monitoring regime and a sanctioning system. States should also be aware that economic and security challenges show the importance of peaceful cooperation between states according to the United Nations treaties. In such an environment, operators can be competitive and cooperative in the international space market. The constant process of commercialization of space requires adapting the existing legislation to current needs and challenges. The economic challenges show the importance of peaceful cooperation between states. As technology progresses and small satellites emerge, access to space becomes easier and cheaper. It favours small countries and their private entities. Free and undistorted competition, in line with the basic principles of operation of democratic states, should be supported by new space programs and strategies and national regulations, so as to make this space available to all. The subject of the article is innovative and new. As there is limited literature available on

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this subject, therefore, there is a clear need to fill this gap. The authors keep the reader informed about the latest updates and information in respect to management, policies and law regulation in the space.

Keywords: space commercialization, space liberalization, space management, space technology dissemination (civil and military), space assets export limitations, space technologies dual-use

INTRODUCTION

As early as the early 1980s, private sector interest in space activities was observed in some Western countries, mainly in the US[1]. The rapid development of commercial activity in space began with the change in the international political situation in the early 1990s when the Soviet Union ceased to be one of the two most powerful nations (the Russian Federation was established over most of its territory). Now, democratic states, mainly the United States, have decided to allow private entities to operate in space, which private entities were flashier and more efficient than state entities. Soon another step in this process took place in space, with government and private companies acquiring private sector services. It is a new business model and a new kind of partnership. Thanks to this, many new technologies and projects were created, and the space industry has become a significant source of GDP growth in some countries.[2]

Government budget allocations for research and development (GBARD) is one of the indicators which provides information about the long-term directions and volume of government-funded R&D (Research and Development) projects. This kind of data is available on OECD (Organisation for Economic Cooperation and Development) and gather economic indicators since the early 1980s. And such, in 2019, civil space R&D (Research and Development) accounted for 0.05% of GDP and almost 13% of total government allocations to civil GBARD (see Figure 1). In the UK, these allocations are 0.006% and 1.36% or for Australia 0.03% and 0.81%, respectively.

The subject of the article is innovative. As there is limited literature available on this subject, there is a clear need to fill this gap. One of the authors has experience in diplomacy work for International Civil Aviation Organization as Polish Council Representative and is a member of the ICAO subgroup of Suborbital Flights. Prior to that, she worked as an expert for the national carrier and national regulator. Her participation in the international organization of the air

[1] R. Skaar, Commercialization of space and its evolution, will new ways to share risks and benefits open up a much larger space market, European space Policy Institute. Report no 4, 2004, p. 5

[2] G.S. Robinson, space jurisdiction and the need for a trans global cybernation: the underlying biological dictates of Humankind dispersal, migration and settlement in near and deep space, "Annals of Air and space Law AASL" 2014, p. 325.

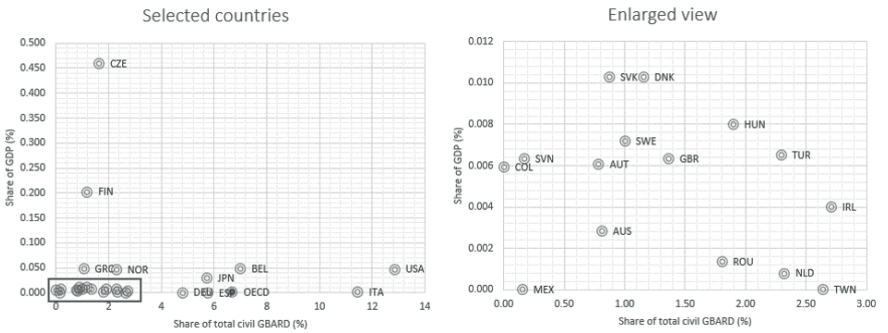

Figure 1. Civil GBARD space programs as a share of GDP and government RD allocations (2019)
Source: OECD (2020), "Main Science and Technology Indicators", OECD Science, Technology and RD Statistics (database), https://doi.org/10.1787/data-00182-en

and space conferences and seminars related to the topic have helped to make this article more relevant.

The subject of this article is new, and the authors keep the reader informed about the latest updates and information in respect to management, policies and law regulation in the space. The entire material included in this article comes from dedicated conferences and seminars about space business and policy organized, in particular, by COSPAR (Committee on space Research) and European space Policy Institute ESPI. Some legal documentation, such as the United Nations treaties or other EU regulations, also were used. In addition, the authors reviewed several articles, which refer to business security or safety published in international journals and own publications in this subject. Below Figure 2 summarizes the current, top published space literature in the global context. The most significant number of papers came from the US, UK and Germany.

This article is divided into the following sections: section 1 considers business and the legal environment, section 2 highlights increases in the activities of private space companies, section 3 treats about the growing importance of small satellites,

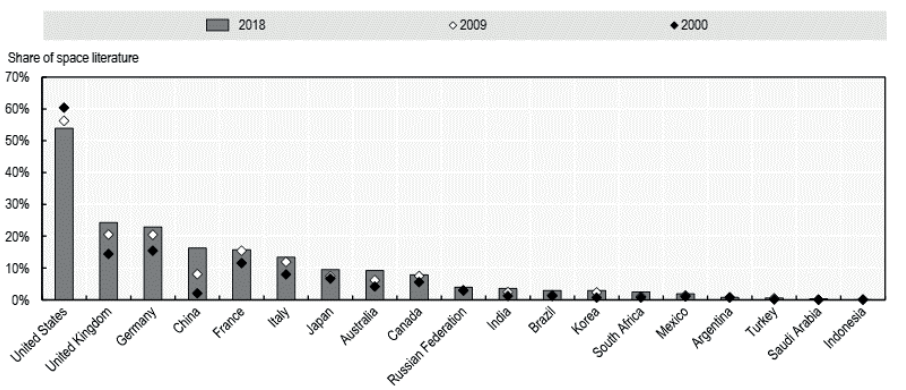

Figure 2. Share of the top published papers in the space literature, per country
Source: Measuring the Economic Impact of the space Sector, OECD, 2020

section 4 discuss commercialization of space in the US, section 5 focus on export control of space equipment, section 6 summarizes activities related to space resources. At the end of the article, final remarks and conclusions are presented.

LITERATURE REVIEW AND THEORY DEVELOPMENT

SPACE BUSINESS AND THE LEGAL ENVIRONMENT

Due to the increasing involvement of private capital and the development of technology, there is a need to explain many issues, such as the differences in interpretations of the concepts of use[3] and exploration, related to space. In the existing space law, treaties and common law, the principle of non-appropriation and freedom of use are strictly established. The analysis of these principles shows that in some cases, they may be contradictory. The possible conflict between use and appropriation challenges the new space law.

There is no definition of the word "use" in space law. The Treaty on the Moon 1979 gives some hints, but it was not adopted by most countries. Some of the rules are contained in the 1967 space system. The most important indication is that the use of space resources, including celestial bodies, is allowed (for example, mining or extracting space resource)[4]. In the absence of international regulations, some states regulate private entities through internal legislation[5]. Thanks to this, the idea of global cooperation between the state and private entities was born[6]. A good example is the regulations governing the activities of the International Space Station (ISS). [7]However, there is still a lack of sufficient legal solutions to regulate, for example, satellite operations. Facilitating satellite lifting should be international standards, independent of political conditions and equal for all, including private entities[8].

In space tourism by space shuttle (RLV), crew, passengers and cargo must be safely returned. The system must be operational and checked for quality; on the other hand, it must bring certain economic benefits. To run such a business,

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3 R. Jakhu, Introduction into the conference 3rd Manfred Lachs International Conference on New space commercialization and the law, 16-17 March 2015, Montreal, ICAO

4 K-H, Böckstiegel, Introductory remarks[in:] Research and Invention in outer space. Liability and Intellectual Property Rights, A. Mosteshar [ed.], Dodrecht, The Netherland 1995, pp. 1-6

5 R. Skaar, op. cit. p. 5

6 J. Monserrat Filho, Why and how to define "global public interest", Proceeding of the forty-third colloquium on the law of outer space, International Institute of space Law of Outer space of the International Astronautical Federation, 2–6 X 2000, Rio de Janeiro, Brazil, pp. 22-32

7 A. Farand, A. Commercialization of International space Station Utilization: The European partner's Viewpoint, "Air and space Law, ASL" 2003, Vol. XXVIII, no 2, pp. 83-88

8 V. Leister, M.C. Frazier, The role of national and international law in the regulation of space activities. Proceeding of the forty-third colloquium on the law of outer space, International Institute of space Law of the International Astronautical Federation, 2–6 X 2000, Rio de Janeiro, Brazil, pp. 164-167

however, numerous procedures are required, in particular related to transportation (ship equipment, types of routes, insurance for the crew and passengers, emergency procedures, spaceport infrastructure and the like).[9]

Commercialization of space activities is a natural result of the continuous development of space technology. However, commercialization causes numerous legal problems, including in connection with civil liability[10]. Some argue that this responsibility should be left to the market alone[11]. space transportation services and telecommunications may require separate and specific international rules. Other authors believe that space flight can take advantage of the fourth and third freedoms (combined), established by the Chicago Convention in 1944 about air transport, are still used in civil aviation today. Transporting a satellite to Earth can be compared to cabotage (a satellite is considered a quasi-state territory)[12].

At present, in some countries, private companies only need to obtain authorization from the state of registration to conduct their activities in space; from a legal point of view, technical and operational access to space is also free[13]. However, not all lawyers are supporters of excessive liberalization of activities in space[14]. According to them, the "international regulator" should take into account the differences of opinion and requirements of states; hence the transport laws and expansion of space activities cannot be the same for all states[15]. Some authors point out the need to create a new branch of space law, that is, the law dealing with commercial activities in space[16].

As already mentioned, back in the 1980s, the United States announced a space technology commercialization program, which included, among others, postulates to ensure favorable conditions for the development of private companies, a continuation of exploration and discoveries, limiting the risk and restrictions

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9 W.A. Gaubatz, International Certification for Commercial Reusable space Transportation, [in:] space law – General Principles, R.S. Jakhu (ed.), Institute of Air and space Law, University McGill, Montreal 2007, Vol. II, pp. 51-57

10 H. Qizhi, Certain legal aspects of commercialization of space activities, "Annals of Air and space Law" AASL, 1990, Vol. XV, pp. 333-342

11 P.D. Bostwick, Liability of aerospace manufacturers: MacPherson v. Buick Sputters into the space age, "Journal of space Law" JSL, 1994, Vol. 22, no 1-2, pp.75-96

12 L. Ravillon, Droits des contrasts spatiaux: quelques thèmes récurrents, "Revue Française de Droit Aérien" RFDAS, 1998, no 2, pp. 61-62

13 H. Wassenbergh, The art of regulating international air and space transportation, an exercise in regulatory approaches to analyzing air and space transportation, "Annals of Air and Space Law" AASL 1998, Vol. XXIII, pp.201-229

14 A. Kerrest, Launching spacecrafts from the sea and the Outer Space Treaty. [in:] Le droit de l'espace et la privatization des activites spatiales, A. Kerrest [ed.], Paris 2003, pp.16-21

15 H. Wassenbergh, Access of private entities to airspace and outer space, "Annals of Air and space Law" AASL, 1999, Vol. XXIV, pp. 311-331

16 P.A. Salin, Orbites, fréquences et asteroïdes a l'heure de la commercialization des activités spatiales (vers une appropriation graduelle du patrimoine de l'espace?), "Annals of Air and Space Law" AASL 2001, Vol. XXVI, pp. 179-195

imposed on space technologies. Many American researchers even believe that US space companies should be allowed to circumvent some regulations until they themselves create the appropriate regulations for space operations.[17]

For the time being, however, jurisdictional issues remain a serious concern for private parties. The concept of responsibility for activities inconsistent with the principles of international law, including the activities of private entities, and the responsibility of the state for damages caused by space objects, including private operators, is becoming a fundamental problem in international space law. States are therefore forced to take internal measures, to monitor and control the activities of private entrepreneurs. Therefore, cooperation between international and national legislation is necessary.

States controlling private enterprises should have the legislative mechanisms needed to establish a licensing and monitoring regime and a system of sanctions. It seems that international law should be left to define the parameters and the scope within which such control of private enterprises should take place. States should be able to decide in which categories private companies should operate[18]. Many countries have introduced laws favoring commercialization in their national law. They include European Union countries and others, such as Australia, which in the Act of 1998 provided protection for the activities of the private space sector[19] or the US, which in the Act of 1984, amended in 1988, introduced certain powers for the private sector[20].

In the commercialization process, apart from ensuring safety and the correctness of operational procedures, what matters is the economic factor (i.e. profitability). Likewise, it is crucial for an appropriate government authority to be authorized to issue commercial spaceports and commercial operating licenses based on an assessment of the operators' ability to ensure public safety and to protect property and the environment. A spaceport is not defined by international law or by US domestic law. In the Oxford dictionary, the term denotes the place from which spacecraft are disembarked, take-off and land. Each spaceport must be adequately equipped and have appropriate facilities. The interests of all parties involved must be protected. Below Figure 3 presents the global map of active, inactive and orbital human launch spaceports.

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17 P.S. Dempsey, Overview of the United State Space Policy and Law [in:] National Regulations on Space Activities. R.S. Jakhu (ed.), Dordrecht, Heidelberg, London, New York, 2010, pp. 374-403

18 F.G. von der Dunk, Public space law and private enterprise, [in:] Space Law – General Principles, R.S. Jakhu (ed.), Institute of Air and Space Law, University McGill, Montreal, 2007, Vol. II, pp.47–471

19 R.J. Lee, The liability convention and private space launch services- domestic regulatory responses. "Annals of Air and Space Law" AASL 2004, Vol. XXXI p.57-87

20 Ch. W. Stotler, International and US national laws affecting commercial space tourism: how ITAR tips the balance struck between international law and the CSLAA (Commercial Space Launch Amendment Act), "Journal of Space Law" JSL, 2007, Vol. 33, no 1, p.268

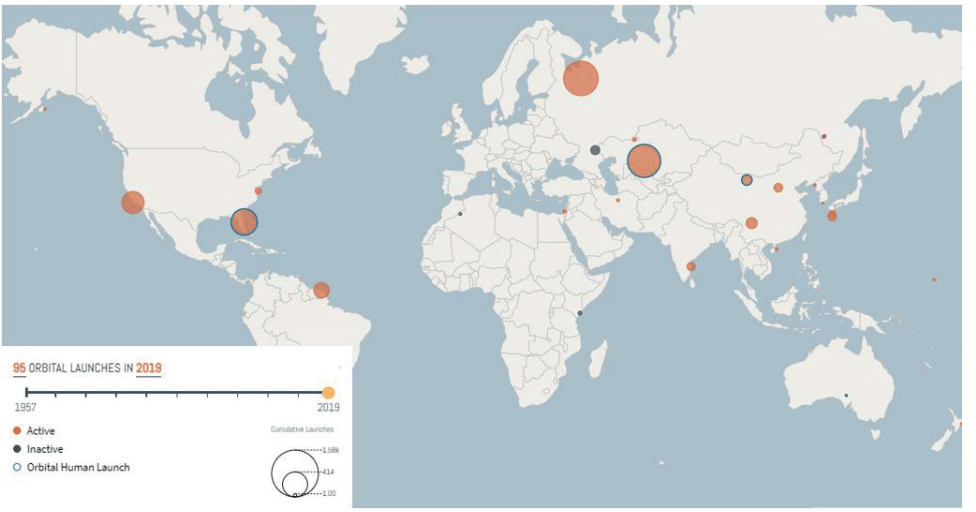

Figure 3. Currently operating spaceports, 2020
Source: Thomasa G. Roberysa World Spaceports (2020), https://aerospace.csis.org/data/spaceports-of-the-world/

In the US, spaceports were initially used only for military purposes, but with time, they also came into private hands. Government spaceports that undertake commercial activities must comply with registration and licensing requirements, as do commercial spaceports (government ports performing government functions are not subject to these regulations). spaceports can be classified as terrestrial or off-Earth[21].

INCREASE IN THE ACTIVITIES OF PRIVATE SPACE COMPANIES

Thanks to the favorable position of some countries, many private companies developed rapidly. Good examples of newly established companies are Nanoracks, Skybox or Made In Space. These new companies were operating with older capital of Bigelow Aerospace, Blue Origin, SpaceX or Virgin Galactic, and older companies using new technologies, such as Orbital Sciences, Boeing or Lockheed Martin. In addition, there are alliances between newer and older market players such as Stratolaunch & Blue Origin in partnership with United Launch Alliance or entrepreneurs who do not deal with space on a daily basis[22].

The below Figure 4 provides information about selected economic state sectors that benefit from space programs (GBARD), including transport, defense and security or energy and more; whereas Figure 5 highlights types of effects

[21] M.C. Mineiro, Law and regulation governing US commercial spaceports: licensing, liability, and legal challenges. "Journal of Air Law and Commerce" JALC, 2008, Vol. 73, no 4, p. 760

[22] R. Jakhu, Introduction into the conference 3rd Manfred Lachs International Conference on New Space commercialization and the law, 16-17 March 2015, Montreal, ICAO

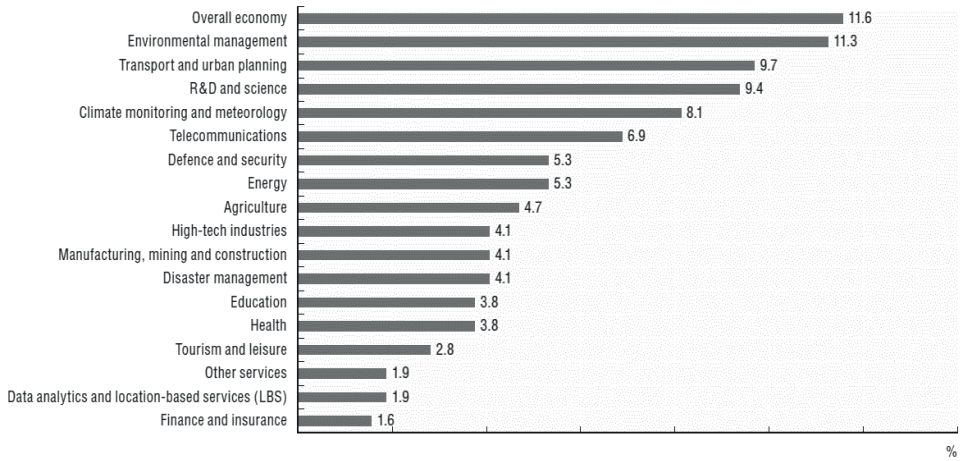

Figure 4. Selected economic sectors that benefit from socio-economic effects derived from space investments (share of total occurrences identified in the literature, 1972-2018)
Source: Measuring the Economic Impact of the Space Sector, OECD, 2020

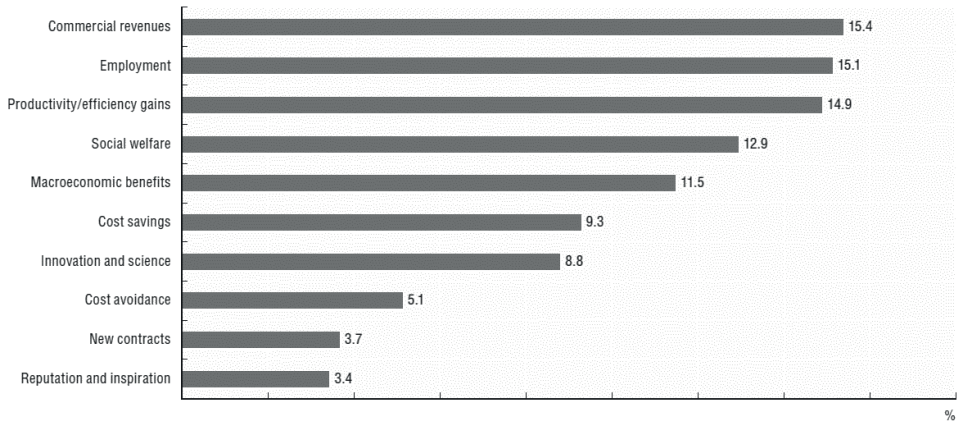

Figure 5. Types of positive effects derived from space investments (share of total occurrences identified in the literature, 1972-2018)
Source: Measuring the Economic Impact of the Space Sector, OECD, 2020

derived from space investments in the world, and this refers to commercial revenues, employment, or social welfare.

Not all activities are already regulated by national law. Even in the United States, not all entrepreneurs know which authority is responsible for issuing appropriate permits for the operation of certain "space companies" and which for overseeing them[23]. The intensification of activities in space (civil and military) requires, first of all, the allocation of more and more funds by states. The pu-

[23] M.C. Mineiro, Regulatory uncertainty for non-traditional commercial space activities 3rd Manfred Lachs International Conference on New Space commercialization and the law, 16-17 March 2015, Montreal, ICAO

blic has relatively the best information on the funds allocated by states for civil space activities. The United States planned the largest budget for civil and defence activities in space in 2019 ($74.48 billion). Japan and Chinese budgets were smaller and constituted only 4.78% and 1.34%, respectively, of the US budget. Among other countries, significant budgets have been adopted by the European Union countries: Germany, the UK and Italy – in total 7.53 billion USD (which constituted approximately 10% of the US budget)[24].

To represents the estimated measures for government space budget spending, the ratio of space budget to the national GDP (Figure 6) has been created. In 2019, the US budget accounted for 0.35% of national GDP, followed by Germany (0.08%), China (0.08$), turkey (0.07%) and Japan (0.07%).

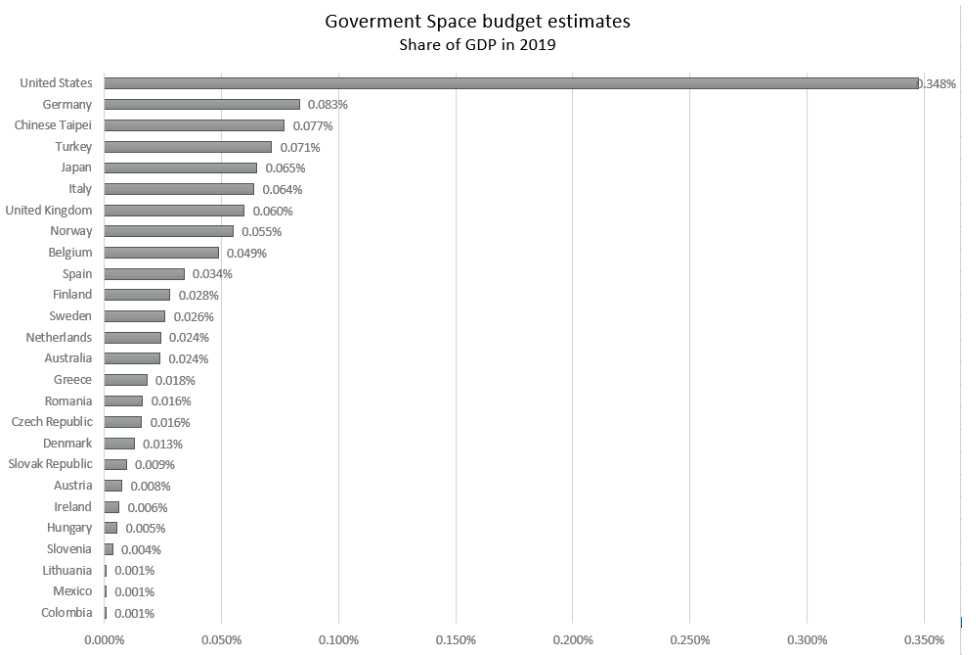

Figure 6. Government space Budget estimates for 2019
Source: OECD (2020), "Main Science and Technology Indicators", OECD Science, Technology and RD Statistics (database), https://doi.org/10.1787/data-00182-en

This US financial advantage over the rest of the world resulted not only from the increased tax burden on its citizens but above all from the innovation of the US space industry.

US space expenditure is accounted for 0.224% of the national income, which is almost twice as much as in France, and more than twice as much as in the

24 OECD (2020), "Main Science and Technology Indicators", OECD Science, Technology and RD Statistics (database), https://doi.org/10.1787/data-00182-en

Russian Federation. Relatively low expenditure for this purpose was anticipated by Great Britain – more than twice less than for India. It can be seen that the US economy allocates (in percentage) less than twice as much from its national product as France. Still, thanks to the leading technology and organization of work, it obtains more than sixteen times more funds than this country. Even worse results are obtained by the Russian Federation, which allocates more than two times less national income to the space economy than the United States but obtains almost 28 times fewer funds from these investments than the United States. In 2017, the largest expenditure on space activities per capita was to be: 133.20 USD in the USA, almost 41USD in France (i.e. over three times less than in the USA), in the Russian Federation 10.21 USD, and China – 5.76USD.

The increase in financial outlays for space purposes has resulted, among others, to a rise in the number of satellites launched and other space devices (refer to Figure 7). In 2017, the largest number of satellites was launched by the USA (154), followed by India and Russia. The largest number of this type of devices was launched by private companies 289 fires (i.e. 61.3%), while state--owned companies recorded 80 fires, (i.e. 27.7%). State-owned companies seem to have launched more satellites, and private companies have launched fewer satellites, and the number of military satellites appears to be understated[25]. As of March 31, 2019, the number of operational satellites was 2,062, of which the United States accounts approximately for 47.3% of all satellites, ahead of European countries (14.9%) and China (14.5%). Other entities own about 19.5% of these devices. Most of the satellites are in the orbits, such as LEO (approx. 65%) and GEO (approx. 27%); while the largest number of satellites is used in communication (approx. 37.5%) and Earth observation (approx. 37.2%).

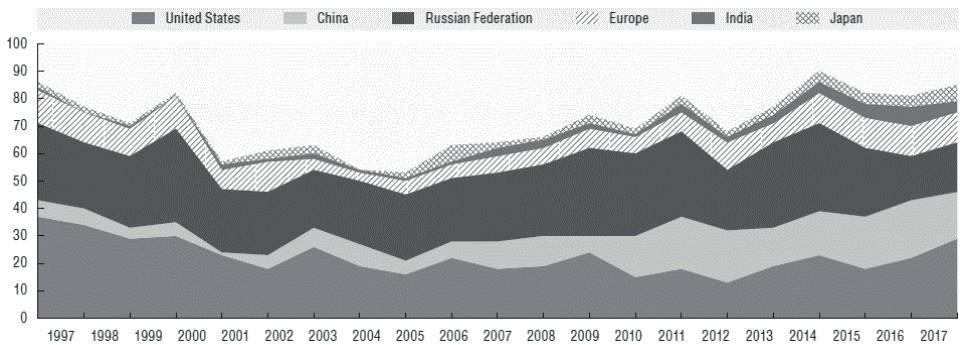

Figure 7. Satellites launched between 1957 and 2018
Source: Measuring the Economic Impact of the space Sector, OECD, 2020

25 E. Burger, G. Bordaccini, Yearbook on Space Policy 2017. Security in Outer Space: Rising Stakes for Civilian Space Programmes. Edited by the European Space Policy Institute, Cham, Switzerland, 2019

Currently, a characteristic feature of large space projects is not only the cooperation of many companies and people from many countries but also the longtime of their implementation. Nevertheless, their results are very favorable, for example, from an economic point of view. For example, the European GALILEO (Copernicus) program for monitoring earth disasters (land, sea and air) offers the potential to create up to 85,000 new jobs. Other projects also contribute to faster development. enterprises engaged in activities in space[26].

THE GROWING IMPORTANCE OF SMALL SATELLITES

In recent years, small satellites have played an increasing role; According to the calculations of the international consulting company Euroconsult, about 500 small satellites worth about USD 7.4 billion are planned to be launched in the next 5 years. The mini-satellites weigh less than 1000 kg, micro – less than 100 kg, nano -10 kg and pico -1 kg (refer to Table 1). There are also satellites called cube sats in the shape of cubes with the parameters of 10x10x10x10 cm and weighing from 10 to 100 grams. These satellites land mainly in lower orbits, usually without fuel. However, they have different applications and structures, are more or less complex, have different radio frequencies, and use different types of frequency technology. They are used by a number of entities (private companies, governments and their agencies, armed forces, universities, research centers, and even private individuals). Small satellites are used in both rich and developing countries. They can be launched even by small devices from the surface of the Earth, sea, air or space[27].

Source; E. Burger, G. Bordaccini, Yearbook on Space Policy 2017. Security in Outer space: Rising Stakes for Civilian Space Programs

Small satellites offer many possibilities to use space for various purposes. They are the main tool in the development of space commercialization and at the same time, a challenge to the existing international treaties and national regulations. In addition, some authors believe that new space regulations are needed for the safe conduct of private economic activities, but not the so-called soft law because it is not strong enough. The importance of cooperation between states in areas such as space management or environmental protection is also underlined[28]. Table 2 provides some information in reference to the number of satellites produced and launched by selected companies, such as CAST, Airbus or Lockheed Martin.

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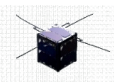
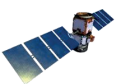
26 European Space Policy Institute "ESPI", Report 71, Towards a European Approach to space Traffic Management- Full Report. Published January 2019, [ed.]European Policy Institute (ESPI), Vienna, Austria, p. 15

27 A. Cazenave, Monitoring Sea Level Change from Space, "Space Research Today", 2019, August, no 205, p.49

28 K. Uwe Schrogl, Regulations for future space traffic control and management, [in:] J. Pelton and R. S. Jakhu, Introduction to space safety regulations and standards, Nidjihof, the Netherland 2010, pp. 303-308

Table 1. Types of satellites launched in 2017

type of satellite		number of satellites launched	Percentage	average satellite weight in kilograms	Total mass of satellites in kilograms
Nano		288	61.1%	4.3	1,238
Micro		30	6.4%	43.3	1,300
Mini		29	6.2%	266.6	7,732
Large		124	26.3%	3149.1	390,483
Total		471	100%	850.9	400,754

Source; E. Burger, G. Bordaccini, Yearbook on Space Policy 2017. Security in Outer space: Rising Stakes for Civilian Space Programs

The production and operation of small satellites are cheaper; therefore, private entities have undertaken to manufacture and launch them. The problem, however, is that manufacturers of small satellites are not very experienced and government regulators are used to large facilities. Hence the need to introduce into national law provisions relating to small satellites, including their insurance, development of registration rules[29], environmental protection (including the disposal of residues)[30]. These principles should be balanced[31]. Financial issues or risk minimization would be less flexible[32]. It is also related to the problem of the end-of-life predictability of the satellites. Large satellites can operate for several years (and the modernized technologies will be able to reach even several dozen

29 N. Palkovitz, Small satellites and developments in space law; International Air and space Law Conference, Gdańsk, Poland. November 15 2013

30 I. Marboe, K. Trunmuller, Small satellites and small states: new incentives for national space legislation, "Journal of Space Law", JSL, 2012, Vol. 38, no 2, p.318

31 S. Freeland, New space, small satellites and law: finding a balance between innovation, a changing space Paradigm and Regulatory Control, 3rd Manfred Lachs International Conference on New space commercialization and the law, 16-17 March 2015, Montreal, ICAO

32 M. Othman, A. Matas, 3rd Manfred Lachs International Conference, 16-17 March 2015, Montreal, ICAO

Table 2. Number of satellites produced by selected companies and launched in 2017

Company name, country, region	Number of satellites produced and launched		Military purpose only	Civil-government missions	civil-military missions	Commercial purposes
	Number	Percent				
CAST, China	10	9.6	-	6	2	2
Airbus, Europe	7	6.7	-	3	-	4
Thales Alenia space, Europe	45	43.3	-	-	-	45
ISRO, India	8	7.7	-	7	1	-
Mitsubishi Electric, Japan	5	4.8	-	4	1	-
ISS Resztniew, Russia	1	0.1	-	1	-	-
Boenig, USA	10	9.6	4	1	-	5
Lokheed Martin, USA	3	2.9	3	-	-	-
Orbital ATK, USA	2	1.9	-	2	-	-
space Systems Loral	13	12.5	-	-	-	13
Total	104	99.1	7	24	4	69

Dash: No data of production has been accounted for; Source: E, Burger, G. Bordacchini, op. Cit. p.93

years), smaller ones – they only operate for a few years. A new challenge is also to regulate, in the case of small satellites, the issue of freight transport, which is of interest to an increasing number of private companies[33].

Small satellites are cheap and can be built even by students or non-governmental organizations with a lower budget. Over the 4 years (2010-2014), the number of nano- and micro-satellites increased by 37.2% per year. In recent years, more and more companies, mainly in North America and Europe, declare their interest in such launches. Small satellites can pose a threat to existing technologies as they serve a new market segment and are cheaper to operate. Large companies must take into account the new challenges and threats posed by new players and incorporate these innovations into their programs. It is possible that new technologies, due to their low cost, will threaten banks, insurers and investment funds[34].

For the time being, however, insurance matters for commercial companies (launching large or small satellites) have not been included in the space law. As the 1972 Liability Convention in principle applies only to space activities of states and international intergovernmental organizations; it is also imprecise and

[33] M. Buzdugan, Satellite financing through hosted payloads: benefits and challenges, "Air and space Law" ASL. 2011 Vol 36, no 2, pp.139-160

[34] L. Rapp, V.D. Santos, A. Martin, Entering a New Space era; what might be expected from Satellite Miniaturisation? 3rd Manfred Lachs International Conference on New Space commercialization and the law, 16-17 March 2015, ICAO, Montreal

unclear. In this situation, many private space companies insure their activities in well-known companies with great traditions. For example, Lloyd's has been insuring all communication risks for several hundred years and has been operating in the space field for the last 30 years. During this period, the company raised $4.2 billion in contributions from various entities and paid out $3.4 billion to customers. In recent years, an increase in the number of insured entities and a decline in insurance rates have been noticeable. The average cost of insurance (start-up and annual stay in orbit) is about 10% of the value of the insured cargo; the orbital satellite's insurance premium is approximately 0.5% of the insurance value[35].

Small satellites are usually used to test new products, reducing the risk of mission failure. They are treated as "space objects" in accordance with international rules; however, in practice, they are excluded from the scope of these rules. Nanosatellites will be more and more popular in the future (they can also be used in commercial missions). The most significant risk for them is the possibility of a collision, as they cannot be maneuvered and may be left as space debris. The satellite operator receives the data from him and can send it to a certain level but cannot change the orbit. This raises questions about possible collisions with other objects in lower orbit, but so far nothing has happened. Nanosatellites usually burn when they enter the Earth's atmosphere.

Moreover, the cost reduction factor is crucial at the current times. The below Figure 8 clearly showing the decreasing costs of satellite or space vehicle production and successfully launched. Each circle represents the estimated cost per kilogram in the spread of the past sixty years.

For now, the issue of nanosatellites is treated differently in different countries; in many cases, national legislation has legal loopholes and divergences. For example, under Dutch law, small satellites are exempt from space activities, while under Belgian law they are covered by national law. Under Dutch law, a license is not required to launch such satellites, so the state is not responsible for them. This issue is currently being discussed in parliament – the problem of the blame for collisions is being raised – it is necessary to determine which country will be responsible (if the collision involved a maneuverable object and one that is not a space object). Austria (according to national law 2011) requires their owners to have a license. It also provides for the introduction of other insurance regulations, if the activity is commercial or even scientific and educational[36]. Obtaining such insurance will be difficult because no companies are offering cheap space insurance on the market[37].

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35 M. Polkowska, Prawo bezpieczeństwa w Kosmosie, Warszawa 2018, Instytut Wydawniczy Euro Prawo, pp.220-221

36 N. Palkovitz, T.M. Zwaan, T.M Orbiting under the radar: nano-satellites, international obligations and national space law 55th colloquium on space law s. 578, 2012, Naples

37 J. N. Pelton, R. Jakhu, R.S Small satellites and their regulation, New York 2014, p.1

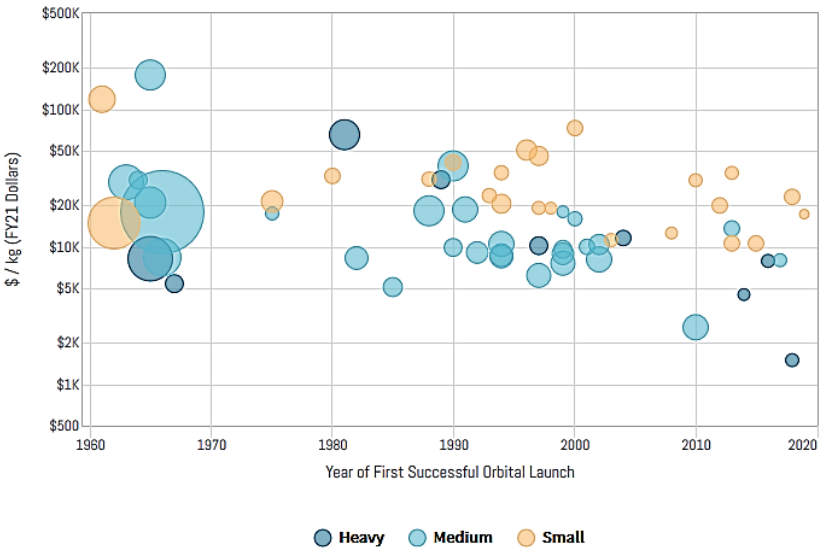

Figure 8. Cost comparison for space launch satellites
Source: Thomasa G. Roberysa World spaceports (2020), https://aerospace.csis.org/data/spaceports-of-the-world/

The increasing availability of low-cost launching equipment provides an opportunity to reduce overall operating costs for enterprises. Moreover, new technologies and computational methods are changing the way data is obtained, managed and processed. The big data created by small satellites will require new rules of analysis. In a 2019 report prepared by the international group of experts within the Space Research Committee, COSPAR, the term "small satellite" is somewhat arbitrarily defined as a spacecraft with an upper mass limit in the range of several hundred kilograms[38]. Yet the mass limit is less important than the processes used to build and launch these satellites[39].The roadmap in this report aims to encourage the space research community to stimulate the development of small-scale satellite industries in order to increase flight frequency and to change the way small scientific satellites are built and managed. Five recommendations were made; one each for the scientific community, the space industry, space agencies, policymakers and finally COSPAR itself.[40]

[38] R. von Steiger, Small satellites for Sustainable Science and Development. Small satellites for space Science (4S), a COSPAR Scientific Roadmap, presentation at Israel, Herzilija CO-SPAR meeting 4-8 November 2019

[39] Small satellites for space science, a COSPAR scientific roadmap. Advances in Space Re-search. Robyn M. Millan, Rudolf von Steiger, Meir Ariel, Sergey Bartalev, Maurice Borgeaud, Stefano Campagnola, Julie C. Castillo-Rogez, Rene' Fle'ron, Volker Gass, Anna Gregorio, David M. Klumpar Bhavya Lal, Malcolm Macdonald, Jong Uk Park, V. Sambasiva Rao, Klaus Schilling, Graeme Stephens, Alan M. Title, Ji Wu, 64 (2019) p. 1

[40] https://council.science/what-we-do/research-programmes/thematic-organizations/committee-on-space-research-cospar/ (access 21/08/2020)

In 2017, 36 small Cube Sats were launched to study the upper atmosphere in the EU-organized QB50 constellation. Participating in this program were: Australia, the United States, Canada, China, Taiwan, South Korea, Israel, South Africa, Turkey and Ukraine. Other entities have also collaborated in this field; for example, several new private companies are building rockets for small satellites (e.g. Rocket Labs and Virgin Orbit). It seems that the commercial sector is already developing new ways to build and test small satellites. Significant technological advances open up new opportunities for small satellites[41].

COMMERCIALIZATION OF SPACE IN THE US

Countries, including the US, are increasingly limiting their government budgets due to insufficient funds. Research and Science Prof. Dempsey draws attention to the dynamic pace of development of the private sector in space, especially in the period of decline in government activity. The global cost of government and private space operations increased to $ 314 billion in 2013, but commercial product and service revenues increased to 7%, and state-owned revenues fell[42].

Already in the program of the US government for 2010, it was stated that its task is, inter alia, supporting and facilitating the development of the commercial space sector, thanks to which the US will become a world leader in space. At the same time, an increase in the number of people delegated from private companies was recorded in the American offices and institutions involved in the implementation of the American space program. As a result, there has been an increase in the activity of private companies, including, e.g. Virgin Galactic, Bigelow, Microsoft, Amazon, and the stagnation of some government agencies.

The US government counts on close cooperation between government agencies and experienced private agencies whose operating costs are relatively low, and the results are encouraging. In the near future, the United States anticipates, inter alia, three types of missions: freight and manned transport to the ISS Platform, space flights in the sub-orbital space and reconnaissance missions to Mars. In the case of flights with passengers on board, NASA cooperates with three American airlines. There are currently 8 licensed spaceports in the US, but the number of US spaceports will grow; getting ready for this investment are, among others states, Texas, Hawaii and Colorado. Also, in other parts of the world, new ideas are emerging about the location of attractive spaceports attracting sub-orbital operations (Curacao, Japan, Sweden, Spain, Singapore, UK and

41 A. Freeman, SmallSat Constellations for Earth Science-it's about timing, presentation at the COSPAR meeting, Israel, Herzilya 4-8 November 2019

42 P.S. Dempsey, National legislation governing commercial space activities, Aerospace symposium ICAO. Montreal, March 2015

the United Arab Emirates)[43]. The activity of private entrepreneurs is constantly developing; it concerns not only the transport of passengers but also of satellites (Virgin Galactic). It is even said that there is a new concept of sub-orbital tourism in space. In the US, some entrepreneurs and NASA are also interested in transporting expeditions or building modern asteroid observing telescopes.

Commercial space activities also take place in Europe. Companies such as EADS, Astrium, Swiss space System, Booster, Reaction Engines operate here. Among others, balloon designs that can carry tourists to high altitudes[44].

EXPORT CONTROL OF SPACE EQUIPMENT

The control of the export of space devices (or their components) plays a significant role in the space business; it contributes both to protect national security and the interests of private companies. Entrepreneurs who export or import this type of goods must take into account the diversity of domestic and foreign regulations. Nowadays, export control regulations have become more complex and extensive. US export control laws have had a strong impact on other countries, as the US also applies its domestic regulations to export procedures outside its territory. Therefore, a non-US importer of US goods must comply with applicable US regulations, especially in cases of further re-export of such goods.

Any company or individual in the US can be placed on the so-called blacklisted or subjected to criminal prosecution by authorities in cases of non--compliance with the law. The US regulations also apply to situations where American technologies or information systems are used or are a component of a product outside the US. In the space industry, it is often impossible to do without American components. In this case, the foreign space enterprise is forced to comply not only with domestic regulations but also with American regulations.

In addition, more and more countries are beginning to adopt appropriate legislation to avoid the export of certain goods and equipment to hostile or unstable countries. The exporter needs to know what rules will apply to his export (hardware, software or technology). When controlling exports, goods are sometimes divided into two groups: the "dual-use" category (goods used for civil and military purposes) and the "military" category, for which export regulations are more burdensome.

Certain rules and legal regimes have been established to harmonize export controls at the international level. Also, restrictive national regulations are based on these international rules (including lists of controlled goods). The US export regulations are quite complex as there is no single set of regulations and no single

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43 G.C Nield, A new way to look at things [in:] R. Jakhu, K. W Chen, Regulation of emerging modes of aerospace transportation, McGill, Montreal 2014, p. 21

44 M.E. Dirkx, High hopes and low estimates: new space's rocky contractual road, "Journal of Space Law", JSL, 2010, Vol. 36, no 1, p. 55

licensing authority. There are several departments involved in export control, each with its own regulations[45].

In 1999, the US Congress decided to transfer control of the export of commercial satellites to the Department of State. The reason for this was a dozen incidents involving the export of satellites and modern technology to China. This transfer was deemed to endanger US security. On the one hand, this change had an impact on the US industry, which experienced stagnation in exports due to restrictive and lengthy licensing procedures, and on the other hand, contributed to the strengthening of the space industry in Europe[46].

In order to ensure compliance with international agreements and responsibilities of the European Union Member States, in 1994 the European Commission decided to strengthen the control system of goods that could serve both civilian and military purposes (dual-use) exported to third countries. Pursuant to the EU Regulation No. 428/2009 of 5 May 2009, unified control rules were introduced to ensure international security and allow EU exporters to complete formalities faster.

For the transport of weapons, the European Code of Conduct applies, to the export of weapons and other transfers of defense-related goods – the EU Common Military List, as well as Directive No. 2009/43 / EC of 6 May 2009. Embargoes are managed on the basis of regulations of the European Council. Council Regulation No. 428/2009 for dual-use goods sets the regime for the control of exports, transfers, brokerage and transit services. These rules establish common EU export authorizations. National regulations and decisions regarding dual-use exports must be taken into account in the common trade policy. EU members may adopt their own additional licensing requirements for dual-use as deemed necessary for national security or human rights reasons.

For exports requiring authorization, such documents will be issued by the appropriate authorities of each Member State in which the exporter is established. There are several types of authorization: individual, global, or general. When deciding whether to grant or refuse an authorization, the list of dual-use regulations is taken into account, taking into account: a) obligations and arrangements derived from international treaties, b) sanctions imposed by the European Council, OSCE (Organization for Security and Cooperation in Europe) or by the UN Security Council, c) comments on the national and foreign security policy, d) comments on the intended end-of-life of the goods and the risk of change in use.

The terms and conditions of Directive 2009/43/EC of the European Parliament and of the Council as regards transfers within the Community of defence-

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45 P.J. Blount, The ITAR Treaty and its implications for US Space Exploration Policy and the Commercial Space Industry, "Journal of Air Law and Commerce" (JALC), 2008, Vol.73, p. 705 and next

46 P.S. Dempsey, The evolution of US Space Policy, "Annals of Air and Space Law, AASL 2008, Vol. XXXIII, p. 325

-related goods, according to the authors of the directive, should be simplified. Moreover, when necessary, the list of defence-related products should be updated by the European Commission to align with the EU's common list closely. The member states should determine penalties for breaching the provisions of the directive. The directive does not automatically become part of national law; it still has to be transposed by the law of each Member State. Hence, Member States have to create appropriate national provisions for this[47].

The basic regulations for export control in Germany are the Foreign Trade and Payments Act (Aussenwirtschaftsgesetz – AWG) and the Foreign Trade and Payments Regulation (Aussenwirtschaftsverordnung – AWY) together with the German export list (Ausfuhrliste – AL). The AWG contains the rules of German law for export control, and AWY has specific prohibitions and licensing requirements. The central licensing body for the export is BAFA (translated into English – Federal Office of Economics and Export Control). In some cases, BAFA will decide whether to grant or deny exports. The legal basis for exports is the principles of checking the reliability of the company ("Principles of the Federal Governmental checking the reliability of exporters" of 2001). The authorization is issued only after political consultation with the Federal Minister for Economics and Technology. A unique German requirement for export transactions is the appointment of a person responsible for the export. Such a person must be, for example, a member of the company's board of directors and is personally responsible for compliance transactions with German export regulations. There are the following types of export authorizations: individual, collective (for the export of goods to a dozen or so recipients) and general (the latter are published in the federal newspaper and exclude the issue of individual licenses). All licenses may be provided with specific export restrictions and requirements[48].

In France, the export control system is different from that in Germany; there is no licensing agency. In France, the licenses are issued by the Minister of Defence. However, the French exporter needs his formal approval even to sign an agreement with the importer. Satellites and other space equipment are classified as warfare products. The licensing process can take place in two phases. Firstly, before the proposal is sent, and the contract is signed, a preliminary agreement (Agreement Préalable) must be obtained. Secondly, after it was obtained and restricted by the Secretariat of National Defence (SGDN) on behalf of the French Prime Minister, the Minister of Defence, following a positive recommendation of the inter-ministerial commission for the export of war materials (Commission

47 M. Gerhard, M. Creydt, Safeguarding National Security and Foreign Policy Interest- Aspects of Export Control of space Material and Technology and Remote Sensing Activities in Outer Space [in:] National Space Legislation in Europe: Issues of Authorization of Private Space Activities in the Light of Developments in European Space Cooperation. FG der Dunk (ed). Leiden, the Netherland 2011, pp. 196-219 (www.bafa.de access 20/08/2020)

48 S. Hobe, J. Neumann, Regulation in Space Activity in Germany, [in:] National Regulation of Space, R. S. Jakhu (ed.), Dordrecht, the Netherland, 2010, p. 150

Interministérielle pour l'Etude des Exportations de Matériels de Guerre), admits preliminary consent. There are various scopes and levels that may be authorized by pre-approval. The contract can only be negotiated after obtaining the preliminary consent (sales or negotiation). Then the contract must be compatible with the scope of the preliminary agreement and signed during the validity period of the preliminary contract. Ultimately, the exporting producer has to respect the clauses and restrictions of the draft approval. In the second phase, the manufacturer can obtain a valid export authorization, i.e. AEMG (Autorisation d'Exportation des Matériels de Guerre). However, the export authorization is valid only after obtaining the consent of the Minister of Foreign Affairs and SGDN (on behalf of the prime minister). There are two types of AEMG license: a temporary export license (valid for one year and authorizing the export of items mentioned in the initial approval, and a permanent export license (valid for 2 years and authorizing the permanent export of goods). Products that are not classified as materials used for and associated with warfare may still be considered dual-use[49].

In the UK, important export control regulations are those contained in the Control Act of 2002, along with implementing legislation in various forms (orders). Released in July 2009, Export Control Order 2008 consolidated and updated the 2002 Act, along with legislation on the export of items, technology transfer and technical assistance regulations. The British licensing authority for strategic export control is ECO (Export Control Organization) and BIS (Department for Business, Innovation and Skills). ECO processes all military, nuclear and dual-use export licenses. Licenses are issued (or denied) after receiving opinions from other authorities, such as the Ministry of Defence, DESO (Defence Export Services Organization) or FCO (Foreign and Commonwealth Office). Under UK law, there are the following types of export authorizations: Standard Individual Export License (SIEL), Open Individual Export License (SIEL).

Individual Export License (OIEL), which is specific to an individual exporter and an Open General Export License (OGEL) that allows the export of specific goods controlled by each exporter, provided that the conditions match, and the shipments and runs are elective[50].

The export control system in Russia has much in common with the German system, which was the model for the government of the Russian Federation. Regulations concerning the export control and licensing process are administered by the FSTEK (translated into English – Federal Service for the Technical and Export Control) belonging to the Minister of Defence. The most important export control regulations are contained in the government ordinance No. 691 of 2008. Depending on how sensitive the exports are, the FSTEK may also involve

[49] P. Achilleas, Regulation of Space Activities in France, (in:) National Regulation of Space Activities, R. S. Jakhu (ed.), Dordrecht, the Netherland 2010, p. 121

[50] https://www.pmddtc.state.gov/ddtc_public?id=ddtc_kb_article_pagesys_id=%2024d528fddbfc930044f9ff621f961987 (access 28/08.2020)

an Inter-ministerial Council in the licensing process. Two types of the license can be applied for: (a) single, which allows a certain amount of goods to be exported, and (b) general, which allows export to certain countries without the need to provide an end username[51].

Overall, it can be said that most of the existing national export control laws are based on the international regime. The national rules have the same characteristics; they all distinguish between the categories of export – dual-use and military-use. Some national regimes have only one license (e.g. Germany, UK), while others, e.g. the US and France, have more than one, with different jurisdictions. Unique here is the extraterritorial application in US regulations, which cannot be found in other legislation. In France, too, there is a special rule stating that a preliminary contract is needed to sign a contract consent. Pursuant to European Regulation No. 428/2009, no license is required for du-al-use exports within the EU. National dual-use regulations still exist but must refer to the Council Regulation that prevails in a conflict situation.

ACTIVITIES RELATED TO SPACE RESOURCES

Economic exploration of space is also of great interest; there is even a new concept of "lunar economy". In 2015, the United States adopted a draft law on the commercial use of space (Commercial space Launch Competitiveness Act)[52]. The president orders this draft, acting through appropriate Federal agencies, to facilitate the commercial exploration and commercial sourcing of space resources by US citizens.

Luxembourg, which is not a space power, has adopted similar legislation. The Luxembourg government is very active, organizing symposia and conferences to which it brings experts and business representatives. It also cooperates with other countries and international organizations (e.g. UNOOSA- United Nations Office of Outer Space Affairs) on various space initiatives and projects. It created good economic conditions for companies in the space industry and a useful legal framework for them. The Space Resource Research Center was established. There is also an act that opens the market for external companies to space research (the 2017 Act on the Search and Use of Space Resources). Article 1 of the Act states that: "*space resources may be owned. The search is allowed. The authorization shall be granted to an operator for a mission to explore and use space resources for commercial purposes upon a written request to the ministers*" (Article 3)[53]

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[51] S.P. Malkov, C. Doldrina, Regulation of Space Activities in the Russian Federation (in:) National Regulation of Space Activities.R. S. Jakhu (ed.), Dordrecht, the Netherland 2010, p. 315

[52] Public Law no 114-90: www.congress.gov/bill/114th-congress/house-bill/2262 – (access 11/25/2015).

[53] https://spaceagency.public.lu/en/agency/legalframework/l (access 21/01/2020) law_space_resources_.hml

During the last symposium on this issue, organized by the Luxembourg space Agency (November 13-14, 2019) – the Hague international working group on space management adopted the "Building Blocks for the Development of an International Framework on space Resource Activities ". A working group was set up to promote international cooperation and dialogue with a wide range of stakeholders to identify ways of economic exploitation of space resources[54].

CONCLUSIONS

The constant process of commercialization of space requires adapting the existing legislation to current needs and challenges. The economic challenges show the importance of peaceful cooperation between states. As technology progresses and small satellites emerge, access to space becomes easier and cheaper. It favors small countries and their private entities. Free and undistorted competition, in line with the basic principles of operation of democratic states, should be supported by new space programs and strategies and national regulations, so as to make this space available to all.

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[54] https://www.universiteitleiden.nl/en/law/institute-of-public-law/institute-of-air-space-law/the-hague-space-resources-governance-working-group (access 22/08/2020)

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https://www.pmddtc.state.gov/ddtc_public?id=ddtc_kb_article_page&sys_id=%2024d528fddbfc930044f9ff621f961987 (access 28/08.2020)

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LEGAL ASPECTS OF SPACE EXPLOITATION

Abstract: This essay introduces the current legal setting in the field of exploitation of space resources, the acquisition of which *de facto* determines the possibility of carrying out distant space missions by man. The present paper also points to non-governmental initiatives by the space sector that vocalize what the space sector expects from international legislation. The article also points to the analogies of space to extraterritorial sea areas where the concept of the Common Heritage of Mankind has been implemented, which may be an answer to the question of how to peacefully and effectively manage space resources.

Keywords: space exploitation, space resources, Common Heritage of Mankind, principles of space law.

1. INTRODUCTION

The current technological developments and space research indicate that the exploitation of resources in space will become a necessity in the near future. It is believed that the management of natural resources in outer space is one of the challenges facing the international community in the 21st century[1]. This is mainly due to the need to obtain potential energy sources in order to produce rocket fuel necessary for carrying out closer and further human missions in space. Thus, the search for valuable strategic resources is a necessary step towards the further conquest of space in the spirit of the principles set out in the 1967 Outer Space Treaty[2]

[1] L. Łukaszuk, *Współpraca i rywalizacja w przestrzeni kosmicznej. Prawo-Polityka-Gospodarka*, publ. TNOiK, Toruń 2012, p. 280.

[2] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, opened for signature in the United States, the United Kingdom, and the Soviet Union on 27 January 1967, entering into force on 10 October 1967. https://treaties.unoda.org/t/outer_space (13.03.2021).

and in the 1979 Moon Agreement[3], including the principles of freedom of research and use of space, the principle of non-appropriation of outer space, the principle of the prohibition of the militarization of space, or the principle of the Common Heritage of Mankind[4].

Contrary to popular opinion, in the next century the strategic resources in space will not be gold or platinum[5], or the so-called rare earth metals, including scandium and europium. The geopolitical game in terms of the priority of extraction will concern water, carbon dioxide, helium[6] and oxygen – resources commonly available on the surface of the Earth, and in space occurring, among others, in the resources of regolith (which is the top layer of celestial bodies) and in the deposits of ice or minerals of celestial bodies. The reason for this is that the water resources – apart from the obvious fact of ensuring the possibility of human survival in space – potentially allow the acquisition of liquid hydrogen as a rocket fuel, obtained in the process of electrolysis[7]. Also, carbon dioxide (present, among others on Mars) in combination with hydrogen allows for the acquisition of methane as another potential source of rocket fuel. In turn, the helium isotope 3He can be used in the process of nuclear fusion, potentially allowing for obtaining clean energy in large quantities[8].

There is no doubt that during the implementation of distant space missions (e.g. to Mars) it will not be possible to take a sufficient amount of fuel to safely return to Earth, because if it were technically possible, from an economic point of view, the cost of such a mission would be too high – even on a global

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3 *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, opened for signature on 18 December, 1979.

4 Z. Brodecki [ed.], *Świątynia w kosmicznej wiosce. Bezpieczeństwo przyszłych pokoleń w erze sztucznej inteligencji*, wyd. EuroPrawo, Warszawa 2021, s. 76. Also: K. Lankosz, *Eksploracja i eksploatacja kosmosu. Czy Helium 3 zmieni status prawny przestrzeni kosmicznej?* (w:) E. Fonkowicz [ed.], Prawo międzynarodowe – teraźniejszość, perspektywy, dylematy. Księga Jubileuszowa Profesora Zdzisława Galickiego, wyd. WoltersKluwer, Warszawa 2013, p. 369.

5 Estimates show that selected asteroids orbiting close to Earth have platinum and gold deposits in excess of the amount that has been mined on Earth so far. See: M. Rojewska, *Kosmiczna gorączka złota* (in:) „Kosmos 2017", nr 3/2017, p. 46.

6 It is interesting to note that Poland is one of the six helium producing countries in the world. See: M. Duszczyk, *PGNiG umacnia pozycję głównego producenta helu* (in:) Dziennik Gazeta Prawna, nr 36 (3174) – 21.02.2012, p. A12.

7 M. Hofmannand, F. Bergamasco, *Space resources activities from the perspective of sustainability: legal aspects*, publ. Cambridge University Press, Cambridge 2020, https://www.cambridge.org/core (09.01.2021), p. 2.

8 Despite the fact that the current technology does not yet allow for extensive energy extraction in this process. See: K. Lankosz, *Eksploracja i eksploatacja kosmosu. Czy Helium 3 zmieni status prawny przestrzeni kosmicznej?* (w:) E. Fonkowicz [ed.], Prawo międzynarodowe – teraźniejszość, perspektywy, dylematy. Księga Jubileuszowa Profesora Zdzisława Galickiego, wyd. WoltersKluwer, Warszawa 2013. p. 370.

scale[9]. According to experts, the solution to this problem will be the development of fuel production technology that uses resources available in space. The concept of using space resources in space is abbreviated as ISRU (In situ resource utilization)[10]. For this reason, the search for strategic resources will have to focus mainly on the aforementioned regolith of planets and asteroids as well as ice deposits occurring e.g. on Mars. Therefore, the use of resources available in extraterrestrial space will be necessary if humanity wants to create opportunities for further space exploration[11].

2. LEGAL FRAMEWORK

The time preceding the stage of exploitation of space resources should make the international community reflect on the specification of coherent principles, rules of conduct and social mechanisms that will guarantee humanity peaceful coexistence in the extraterrestrial space, including the exploitation of natural resources. So far, only the framework rules for the use of outer space have been regulated, which, although they are the foundation of the international legal regime of outer space[12], there is a lack of clarity as to the particular problems resulting from the increasingly intense presence of humans in space. This gives rise to more and more ambiguities, and in the era of increased interest in space also by private entities, it is easy to predict disputes emerging with increasing dynamics at the international level.

Pursuant to Art. I of the 1967 Outer Space Treaty, outer space is free for research and use, including free access to all areas of the celestial bodies. The treaty also indicates that space exploration is to be conducted in the interest of all countries as the "province of all mankind"[13]. It is pointed out that the principle of

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9 See: B. Malinowski, *Projekty pozyskiwania naturalnych surowców w kosmosie* (in:) M. Polkowska [ed.], *Współczesne trendy w polityce bezpieczeństwa kosmicznego*, publ. EuroPrawo, Warszawa 2020, p. 95-97.

10 See: Ch. B. Dreyer [ed.], *A new experimental capability for the study of regolith surface physical properties to support science, space exploration, and in situ resource utilization (ISRU)*, publ. Review of Scientific Instruments 89, 064502 2018 (https://doi.org/10.1063/1.5023112 – 10.01.2021).

11 https://weneedmore.space/jak-stworzyc-paliwo-na-marsie/ (10.01.2021). See also: B. Malinowski, *Projekty pozyskiwania naturalnych surowców w kosmosie* (in:) M. Polkowska [ed.], *Współczesne trendy w polityce bezpieczeństwa kosmicznego*, publ. EuroPrawo, Warszawa 2020, p. 96.

12 K. Lankosz, *Eksploracja i eksploatacja kosmosu. Czy Helium 3 zmieni status prawny przestrzeni kosmicznej?* (w:) E. Fonkowicz [ed.], Prawo międzynarodowe – teraźniejszość, perspektywy, dylematy. Księga Jubileuszowa Profesora Zdzisława Galickiego, wyd. WoltersKluwer, Warszawa 2013. p. 369.

13 M. Smirnoff, *Legal Studies on Celestial Bodies*, Journal of Air Law Commerce 1961-1962, vol. 28, p. 290.

the freedom of the Outer Space outlined in this way is something more than an ordinary general clause. It is a milestone for further development of the principles of using outer space and the resources therein, no less important than the work of Hugo Grotius entitled "*Mare liberum*" from 1609[14] for the subsequent development of the international law of the sea, which is now one of the most important factors determining the development of space law[15]. The principle of freedom – which is also characteristic of the law of the sea – is coupled with the principle of the prohibition of the appropriation of outer space as defined in Art. II of the Outer Space Treaty, which forbids the establishment of property rights in celestial bodies. This rule covers the Moon and other celestial bodies and indicates their non-appropriateness by states and the prohibition of declaring the sovereignty of celestial bodies by other entities.

The principle of freedom and the principle of the prohibition of the appropriation of outer space, however, raise many doubts in contemporary reality[16]. First, the Outer Space Treaty did not anticipate that in the 21st century private entities would also take an active part in space exploration[17]. This fact is used by the United States, which unequivocally argues that in its current form, the prohibition of the appropriation of celestial bodies and their resources applies only to states, and not to private entities participating in the conquest of space[18]. Secondly, it is worth pointing to the issue of the exploitation of space resources, which is regulated only with regard to scientific research, at the level of general norms contained in the Outer Space Treaty[19] and in the Moon Agreement[20],

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14 See: J.B. Scott, *Introductory note* (in:) H. Grotius, *The Freedom of the Seas*, publ. Oxford University Press, New York 1916, p. VI.

15 An example of the impact of the law of the sea on the development of space law may be the status of the Area understood as extraterritorial seabed and subterranean seabed outside the jurisdiction of coastal states, which, in accordance with Art. 136 of the UN Convention on the Law of the Sea is the Common Heritage of Mankind.

16 This is also reflected in the fact that only some countries signed or ratified the 1979 Moon Agreement. See: R. Lee, *Law and Regulation of Commercial Mining of Minerals in Outer Space*, publ. Springer – Dordrecht, New York 2012, p. 184.

17 Z. Brodecki [ed.], *Świątynia w kosmicznej wiosce. Bezpieczeństwo przyszłych pokoleń w erze sztucznej inteligencji*, wyd. EuroPrawo, Warszawa 2021, p. 77. However, it is worth pointing out that the first satellite sent into space by the private sector was Telstar-1 sent to Earth orbit by ATT in 1962. See: B. Malinowski, *Projekty pozyskiwania naturalnych surowców w kosmosie* (in:) M. Polkowska [ed.], *Współczesne trendy w polityce bezpieczeństwa kosmicznego*, publ. EuroPrawo, Warszawa 2020, p. 93.

18 S. Gorove, *Interpreting Article II of the Outer Space Treaty* (in:) Fordham Law Review 1968, vol. 37, No. 3, p. 351.

19 The Outer Space Treaty in Art. IV states: "*The exploration and use of the moon shall be the province of all mankind and shall be carried out for the benefit and in the interests of all countries* [...]".

20 See: K. Lankosz, *Eksploracja i eksploatacja kosmosu. Czy Helium 3 zmieni status prawny przestrzeni kosmicznej?* (w:) E. Fonkowicz [ed.], Prawo międzynarodowe – teraźniejszość, perspektywy, dylematy. Księga Jubileuszowa Profesora Zdzisława Galickiego, wyd. Wolters-Kluwer, Warszawa 2013. p. 373.

in the absence of similar regulations on commercial activities in the same scope[21].

The exploration and exploitation of extraterrestrial resources for scientific purposes seems to be widely accepted as consistent with international law[22], while the lack of any standards relating to the commercial exploration and exploitation of space resources seems more and more problematic[23]. As a result, some states engaged in space activities began to "supplement" the international legal framework of space mining through their own acts of domestic law. Among such activities, the legislation of the United States, Luxembourg and the United Arab Emirates should be mentioned[24].

In 2015, the United States passed the Act on ensuring competition in the area of launching objects into outer space – *de facto* supporting American entities in the commercial exploitation of space resources (US Commercial Space Launch Competitiveness Act)[25]. This act in § 51303 provides that "A United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States"[26]. Moreover, in 2020, President Trump's administration issued an executive order to encourage international support for public

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21 Art. 6 sec. 2 of the Moon Agreement indicates that "[...] *the States Parties shall have the right to collect on and remove from the moon samples of its mineral and other substances. Such samples shall remain at the disposal of those States Parties which caused them to be collected and may be used by them for scientific purposes. States Parties shall have regard to the desirability of making a portion of such samples available to other interested States Parties and the international scientific community for scientific investigation. States Parties may in the course of scientific investigations also use mineral and other substances of the moon in quantities appropriate for the support of their missions*".

22 B. Skardzińska, *Górnictwo kosmiczne – prawo i perspektywy* (in:) K. Myszona-Kostrzewa, E. Mreńca, P.B. Zientarski [ed.], *Prawne aspekty działalności kosmicznej*, publ. Kancelaria Senatu, Warszawa 2019, p. 176.

23 See: F. Tronchetti, *Legal aspects of space resource utilization* (in:) F. van der Dunk, F. Tronchetti [ed.] *Handbook of space law*, Northampton 2015, p. 777. Also: Z. Galicki, *Status prawny kosmosu* (w:) A. Wasilkowski [ed.], *Działalność kosmiczna w świetle prawa międzynarodowego*, publ. Ossolineum, Wrocław-Warszawa-Kraków 1991, p. 15. Also: B. Malinowski, *Projekty pozyskiwania naturalnych surowców w kosmosie* (in:) M. Polkowska [ed.], *Współczesne trendy w polityce bezpieczeństwa kosmicznego*, publ. EuroPrawo, Warszawa 2020, p. 97.

24 S. Freeland, *Common herritage, not common law: How international law will regulate proposals to exploit space resources* (in:) Questions of International Law 2017, vol. 35, p. 20.

25 M. Polkowska, *Współczesne problemy zagospodarowania przestrzeni kosmicznej: warunki prawne, współpraca i konkurencja* (in:) M. Polkowska [ed.], *Współczesne trendy w polityce bezpieczeństwa kosmicznego*, publ. EuroPrawo, Warszawa 2020, p. 40.

26 See: *US Commercial Space Launch Competitiveness Act* 2015, § 51303. This law stipulates, however, that the United States does not grant itself any jurisdiction or sovereignty over any celestial body.

and commercial sourcing of resources from Outer Space[27]. This regulation also expresses the position that the United States, faced with doubts about the Moon Agreement, does not perceive space as a world heritage ("the United States does not view it as a global commons").

On the other hand, Luxembourg, despite the fact that it is still not a major tycoon of the space sector, has been intensifying projects supporting the space business since the beginning of the 21st century, creating favorable conditions for the development of this industry and cooperating with other countries and international organizations, such as the United Nations Office for Outer Space Affairs (UNOSA). The result of this activity was the establishment of the European Space Resources Innovation Center (ESRIC)[28], as well as the extensive legislative activities of Luxembourg[29]. In 2017, the Luxembourg legislation adopted the law on the exploration and use of space resources (*Loi du 20 juillet 2017 sur l'exploration et l'utilisation des ressources de l'espace*)[30], which allows for the acquisition of space resources by entities registered in Luxembourg "without violating international law"[31]. The United Arab Emirates (in agreement with Luxembourg in 2017[32]) are also developing the space industry very dynamically[33], which results in intensive legislative measures regulating the activities of private entities in space.

The above-mentioned legislative activities of the United States and Luxembourg have met with wide criticism in the doctrine[34], as well as in the forum of The Committee on the Peaceful Uses of Outer Space (COPUOS). The reason for the aforementioned criticism is the possible appropriation of mineral resources mined on the moon and other celestial bodies, which may lead to competition between space mission integrators and, as a result, pose a threat to both ecological and military security. It can be pointed out that such practices may be an expression of a tendency to assume the primacy of domestic law over international

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27 Full text: https://trumpwhitehouse.archives.gov/presidential-actions/executive-order-encouraging-international-support-recovery-use-space-resources/ (15.09.2021).

28 See: https://www.esric.lu (05.08.2021).

29 M. Polkowska, *Współczesne problemy zagospodarowania przestrzeni kosmicznej: warunki prawne, współpraca i konkurencja* (in:) M. Polkowska [ed.], *Współczesne trendy w polityce bezpieczeństwa kosmicznego*, publ. EuroPrawo, Warszawa 2020, p. 40.

30 The text of the Luxembourg law is available at: http://legilux.public.lu/eli/etat/leg/loi/2017/07/20/a674/jo (5.02.2021).

31 See: B. Skardzińska, *Górnictwo kosmiczne – prawo i perspektywy* (in:) K. Myszona-Kostrzewa, E. Mreńca, P.B. Zientarski [ed.], *Prawne aspekty działalności kosmicznej*, publ. Kancelaria Senatu, Warszawa 2019, p. 174-175.

32 See: https://space-agency.public.lu/dam-assets/press-release/2017/2017-10-10-press-release-mou-space.pdf (25.04.2021).

33 The United Arab Emirates launched its first astronaut into space in 2019.

34 See: M. Hofmannand, F. Bergamasco, *Space resources activities from the perspective of sustainability: legal aspects*, publ. Cambridge University Press, Cambridge 2020, https://www.cambridge.org/core (09.01.2021), p. 2.

law, including in the aspect of the principles of using space resources[35], and this would in turn require a fundamental redefinition of public international law[36].

It is worth noting that pursuant to Article 1 of the Outer Space Treaty, mining activities carried out for peaceful purposes and for the good and interest of all states (e.g. for scientific purposes) are permitted. Therefore, some countries and other entities conducting space activities will certainly argue that all activities in space will have a peaceful, scientific value and in the interest of all countries, and more broadly – for the good of the human mankind. Even if in reality it will pursue only particular goals. This undoubtedly heralds a dispute over space resources, which in turn forecasts the emergence of international jurisprudence and arbitration in this area[37].

Already now it is possible to indicate the arbitration institutions competent for the settlement of disputes arising from the use of outer space. These include the International Court of Air and Space Arbitration[38], the Permanent Court of Arbitration in The Hague[39] and the Court for Private Dispute in Space – established in 2021 in Dubai[40]. However, as it seems at this stage, the creation of space arbitration tribunals is only temporary (or even cyclical), which may be aimed primarily at gaining publicity regarding the ambitious plans for the conquest of space by subsequent countries joining the „race" for the status of integrator of space missions. It seems that the international community specifies the expectations regarding the establishment of the International Court of Space Law, or the creation of an additional chamber in the International Court of Justice in The Hague, as judicial organs operating under the aegis of the United Nations and thus having greater persuasive power[41].

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35 Z. Brodecki [ed.], *Świątynia w kosmicznej wiosce. Bezpieczeństwo przyszłych pokoleń w erze sztucznej inteligencji*, wyd. EuroPrawo, Warszawa 2021, p. 83.

36 See: K. Lankosz, *Eksploracja i eksploatacja kosmosu. Czy Helium 3 zmieni status prawny przestrzeni kosmicznej?* (w:) E. Fonkowicz [ed.], Prawo międzynarodowe – teraźniejszość, perspektywy, dylematy. Księga Jubileuszowa Profesora Zdzisława Galickiego, wyd. Wolters-Kluwer, Warszawa 2013. p. 369-375.

37 Z. Brodecki [ed.], *Świątynia w kosmicznej wiosce. Bezpieczeństwo przyszłych pokoleń w erze sztucznej inteligencji*, wyd. EuroPrawo, Warszawa 2021, p. 76.

38 *International Court of Air and Space Arbitration* was established in 1994 by the *Société Française de Droit Aérien et Spatial*. See: Carson W. Bennett, Houston, *We Have an Arbitration: International Arbitration's Role in Resolving Commercial Aerospace Disputes in Resolving Commercial Aerospace Disputes* (in:) Pepperdine Dispute Resolution Law Journal, Volume 19 Issue 1 Article 2, p. 11 -13.

39 In 2011, the Administrative Council of the Permanent Court of Arbitration in The Hague adopted Optional Rules for Arbitration of Disputes Relating to Outer Space Activities. See: K. Michałowska, *Rozstrzyganie sporów związanych z działalnością kosmiczną* (in:) K. Myszora-Kostrzewa, *Kosmos w prawie i polityce, prawo i polityka w kosmosie*, Warszawa 2017, p. 90-92.

40 https://www.timesofisrael.com/dubai-creates-space-court-for-out-of-this-world-disputes/ (25.05.2021)

41 See: Z. Brodecki [ed.], *Świątynia w kosmicznej wiosce. Bezpieczeństwo przyszłych pokoleń w erze sztucznej inteligencji*, wyd. EuroPrawo, Warszawa 2021, p. 82.

3. NON-GOVERNMENTAL INITIATIVES

In the meantime, bottom-up initiatives are emerging that can generate a persuasive potential for the entire international community in aspect of developing consistent principles and rules for the exploitation of space resources. Undoubtedly, this includes an interesting project created as part of the "Hague International Space Resources Governance Working Group", which was created at a symposium organised in 2019 by the Luxembourg Space Agency in order to promote international cooperation between states and other entities of international law (consortia and private entities) in terms of the exploration and exploitation of outer space. As a result of this group's efforts, a document was developed under the name "Building Blocks for the Development of an International Framework on Space Resource Activities"[42]. The main goal of this project is to create the right conditions for inspiring the development of space mining, which would take into account the interests of the entire international community and, more broadly, all of humanity[43]. As indicated in the document, space resources are understood to mean „an extractable and/or recoverable abiotic resource *in situ* in outer space". In this approach, resources include minerals and volatile materials (gases), including water, but this concept does not include orbits of satellites, the range of radio waves and solar energy[44].

The subjective scope of the Building Blocks in question includes countries, international organisations and non-governmental entities that are more and more boldly involved in commercial space projects. In turn, taking into account the territorial scope, the provisions of Building Blocks include mining activity on celestial bodies (planets, moons and asteroids) in the Solar System[45]. It seems that the territorial limitations resulting from the discussed document result rather from the regulatory realism of the creators of Building Blocks, the lack of which could cause the destructive phenomenon of creeping claims of states and private entities against the areas outside the Solar System, which would be unattainable for humans in the coming years. Therefore, the legal status of space resources outside the Solar System remains beyond consideration in the near term as to the possible principles of their use.

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42 See: Building Blocks for the Development of an International Framework on Space International Space Resources Resource Activities, https://www.universiteitleiden.nl/binaries/content/assets/rechtsgeleerdheid/instituut-voor-publiekrecht/lucht–en-ruimterecht/space-resources/revised-building-blocks-following-the-meeting-of-april-2019.pdf (28.04.2021).

43 Building Blocks ..., p. 1. By such definition of goals, it is possible to deduce the convergence of the intentions of the authors of the document with the institution of the Common Heritage of Humankind, included, *inter alia*, in the Moon Agreement of 1979, which can also be regarded as an element of practice necessary for the formation of an international custom relating to the international status of outer space.

44 Building Blocks…, p. 2, note 2.

45 See: Building Blocks…, p. 2, section 3.1. and 3.2.

Building Blocks proposes 17 principles that should be followed by the international community when developing internationally binding rules for the exploitation of space resources[46]. These include:

1. The principle of coherence of the international framework and activities with international law;
2. The principle of the gradual development of law in the field of the exploitation of space resources;
3. The principle of promoting national and international coherence in legislative activities related to the use of space resources;
4. The principle of sustainable development;
5. The principle of counteracting disputes related to the exploitation of resources;
6. The principle of safe utilization of waste from space mining;
7. The principle of sustainable, rational and efficient use of space resources;
8. The principle of the use of sustainable technologies;
9. The principle of legal certainty and predictability in relation to mining operators;
10. The principle of taking into account the needs of developing countries;
11. The principle of taking into account the needs of science;
12. Principle of taking into account the contribution of pioneer space mining operators;
13. The principle of using space resources solely for peaceful purposes;
14. The principle of using space resources in the interests of all states and humankind;
15. The principle of consultation in accordance with Art. IX of the Outer Space Treaty in the event of a possible threat arising from the exploitation of space resources;
16. The principle of not disrupting other space activities by exploiting resources;
17. The principle of international cooperation in the field of the exploitation of space resources in accordance with international law.

Importantly, Building Blocks formulate in point 4.3a the principle that "Space resources shall be used exclusively for peaceful purposes". Moreover, further provisions say that "Space resource activities shall be carried out for the benefit and in the interests of all countries and humankind irrespective of their degree of economic and scientific development"[47]. These provisions lead to reflection on their similarity to the institution of the Common Heritage of Humankind from the UNCLOS Convention[48], as well as the identical mechanism formulated by the

[46] Building Blocks…, p. 2-3, note 4.

[47] See: Building Blocks…, p. 3, note 4.3b).

[48] United Nations Convention on the Law of the Sea (UNCLOS) – signed on 10 December, 1982. See: M. Nyka, *International Seabed Authority and environmental deep-sea stewardship – prin-*

Moon Agreement of 1979. Pursuant to Art. 136 of the UNCLOS Convention "The Area and its resources are the common heritage of mankind", which means that the seabed of seas and oceans outside state jurisdiction has extraterritorial and unappropriated status, is subject to international supervision, may be used only for peaceful purposes, and benefits from exploitation of its resources are shared with the international community[49].

4. THE CONCEPT OF THE COMMON HERITAGE OF MANKIND

The concept of the common heritage of mankind is considered to be part of the third generation of human rights of a collective nature[50]. It is also widely developed in the law of the sea, and its technical beginning came from the proposal of the representative of Malta in 1967 at the UN forum[51]. The mechanism of the common heritage of mankind has been functioning for several decades in the United Nations Convention on the Law of the Sea (UNCLOS), where it is indicated that the common heritage of mankind is to ensure fair rules for the exploitation of marine resources, in order to benefit the entire international community, in particular for developing countries (Art. 155.2 UNCLOS). As indicated in European literature, the construction of the common heritage of mankind consists of five elements[52]:

1. territorial element – consisting in the recognition that the seabed is not subject to appropriation;
2. research element – consisting in the freedom of scientific research;
3. ecological element – consisting in preserving the fauna and flora of the oceans;
4. exploitation element – consisting in the use of natural resources in the interest of the entire international community;
5. military element – the use of the seabed solely for peaceful purposes.

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ciples governing the protection and use of seabed resources (in:) Maritime Law, vol. XXXIX, Gdańsk 2020, p. 12-14.

49 See: M. White, *The Common Heritage of Mankind: An Assessment*, publ. Case Western Reserve Journal of International Law, Issue 3, 1982, p. 535-537. Also: F. Tronchetti, *Legal aspects of space resource utilization* (in:) F. van der Dunk, F. Tronchetti [ed.] *Handbook of space law*, Northampton 2015, p. 790.

50 J.E. Noyes, *The Common Heritage of Mankind: Past, Present, and Future* (in:) Denver Journal of International Law Policy, Volume 40, Number 1, 40th Anniversary Edition, Article 24, 2020, p. 458.

51 M. Nyka, *International Seabed Authority and environmental deep-sea stewardship – principles governing the protection and use of seabed resources* (in:) Maritime Law, vol. XXXIX, Gdańsk 2020, p. 12.

52 E. Riedel, *Die Menschenrechte der dritten Dimension als Strategie zur Verwirklichung der politischen und sozialen Menschenreichte*, (Translation: Jerzy Zajadło in:) Ruch Prawniczy, Ekonomiczny i Socjologiczny, Rok LII – zeszyt 3-4, Warszawa 1990, p. 122.

The construction of the common heritage of mankind also affects other extraterritorial areas, including of course Outer Space and its natural resources[53], as evidenced by the 1979 Moon Agreement[54], the practice of states, or even the aforementioned Building Blocks created as part of the Hague International Space Resources Governance Working Group[55]. The roots of this concept go back to the doctrine of *Mare liberum* (Hugo Grotius) and later thoughts that indicate the need for international management of natural resources[56]. However, during the design work on the Moon Agreement, there were discrepancies in positions regarding the principles of the exploitation of space resources, which, by the way, was an obstacle to the wider recognition of the norms of the Moon Agreement[57]. The international community has achieved full consensus only in the aspect of the exploitation of space resources for scientific purposes, which was reflected in Art. 6.2 The Moon Agreement. As for the commercial rules for the exploitation of space resources, during the negotiations on the content of the Moon Agreement (primarily at the United Nations Committee on the Peaceful Uses of Outer Space – COPUOS forum), representatives of states pointed to arguments that appear to this day.

As an example, the representative of Belgium, negotiating the content of the Moon Agreement, described the issue of the status of cosmic natural resources as still "philosophical", and the French delegate indicated that the law requires precisely defined concepts, and in terms of the exploitation of space resources, we are dealing with a still unknown field of human activity[58]. Meanwhile, the United States, through its factual actions, from the very beginning showed in the international sphere the recognition of the possibility of acquiring the right of ownership to celestial bodies or their component parts (e.g. resour-

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53 *Ibidem*, p. 122-123.

54 Z. Brodecki, K. Malinowska, M. Polkowska, *Nowa cywilizacja kosmiczna. Satelity w służbie Ziemi*, publ. EuroPrawo, Warszawa 2019, p. 246.

55 However, there are also opposing positions in the literature suggesting that the institution of the common heritage of mankind raises a lot of controversy and has a more political intentions. See: K. Lankosz, *Eksploracja i eksploatacja kosmosu. Czy Helium 3 zmieni status prawny przestrzeni kosmicznej?* (w:) E. Fonkowicz [ed.], Prawo międzynarodowe – teraźniejszość, perspektywy, dylematy. Księga Jubileuszowa Profesora Zdzisława Galickiego, wyd. WoltersKluwer, Warszawa 2013. p. 373-374. Also: A. Wyrozumska, *Ewolucja statusu prawnego Antarktyki a państwa trzecie*, Łódź 1995, p. 66-68; J. Stańczyk, *Pojęcie wspólnego dziedzictwa ludzkości w prawie międzynarodowym* (in:) Państwo i Prawo 1985, z. 9, p. 55-76.

56 M. Dragun-Gertner, *Realizacja idei wspólnego dziedzictwa ludzkości w działalności regulacyjnej ISBA* (in:) C. Mik, K. Marciniak [ed.] *Konwencja NZ o prawie morza z 1982 r. W piętnastą rocznicę wejścia w życie*, Warszawa 2009, p. 276.

57 By the end of July 2021, only 22 countries had signed or ratified the Moon Agreement. See: https://treaties.un.org/pages/ViewDetails.aspx?src=TREATYmtdsg_no=XXIV-2chapter=24-clang=_en (31.07.2021).

58 UN doc. A/AC.105/C.2/SR.204, p. 95. See: A. Górbiel, *Międzynarodowe Prawo Kosmiczne*, Warszawa 1985, p. 138.

ces)[59]. After all, the most effective lobby represented a group of developing countries, demanding a treaty regulation of the legal regime for space resources and adopting the so-called the Argentinean formula of 1970[60], stipulating that space resources constitute the common heritage of all mankind. It was argued that the construction of the rules for the exploitation of resources should be based on the international regime, which was to ensure a fair distribution of the benefits of the exploitation of space resources also among countries not directly participating in a particular space mission[61]. Ultimately, during the design work on the contract, the Argentinean formula prevailed, stipulating that "The moon and its natural resources are the common heritage of mankind [...]"[62].

After several years of negotiations, the concept of the common heritage of mankind was successfully introduced into the Moon Agreement, and the solutions adopted include the 5 components mentioned, creating the mechanism of the common heritage of mankind known from the United Nations Convention on the Law of the Sea (UNCLOS): in Art. 3 of the Moon Agreement there is a political and military element, in Art. 6 research, in Art. 7 ecological element. The territorial element can be found in Art. 11.1 and 11.2, and in addition in Art. 11.3-7, one can find exploitation elements that make the possibility of extracting natural resources from the Moon and other celestial bodies dependent on the creation of a regime at the international level regulating their exploitation and use[63]. This regime – in accordance with Art. 11.7 of the Moon Agreement – is to pursue the following goals[64]:

a) The orderly and safe development of the natural resources of the moon;
b) The rational management of those resources;
c) The expansion of opportunities in the use of those resources;
d) An equitable sharing by all States Parties in the benefits derived from those resources, whereby the interests and needs of the developing countries, as well as the efforts of those countries which have contributed either directly or indirectly to the exploration of the moon, shall be given special consideration.

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59 See: Z. Brodecki [ed.], *Świątynia w kosmicznej wiosce. Bezpieczeństwo przyszłych pokoleń w erze sztucznej inteligencji*, wyd. EuroPrawo, Warszawa 2021, s. 77.

60 https://legal.un.org/avl/ha/agasmocb/agasmocb.html (02.08.2021). In 1970 Argentina presented a draft agreement on the principles governing activities in the use of the natural resources of the moon and other celestial bodies.

61 See: A. Górbiel, *Międzynarodowe Prawo Kosmiczne*, Warszawa 1985, p. 138.

62 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (1979), Art. 11. See: K. Lankosz, *Eksploracja i eksploatacja kosmosu. Czy Helium 3 zmieni status prawny przestrzeni kosmicznej?* (w:) E. Fonkowicz [ed.], Prawo międzynarodowe – teraźniejszość, perspektywy, dylematy. Księga Jubileuszowa Profesora Zdzisława Galickiego, wyd. WoltersKluwer, Warszawa 2013. p. 373.

63 See: B. Skardzińska, *Górnictwo kosmiczne – prawo i perspektywy* (in:) K. Myszona-Kostrzewa, E. Mreńca, P.B. Zientarski [ed.], *Prawne aspekty działalności kosmicznej*, publ. Kancelaria Senatu, Warszawa 2019, p. 173.

64 See: Z. Brodecki, K. Malinowska, M. Polkowska, *Nowa cywilizacja kosmiczna. Satelity w służbie Ziemi*, publ. EuroPrawo, Warszawa 2019, p. 247.

However, as mentioned earlier, already during the preparatory work on the Moon Agreement, divergent positions of states emerged, related to the principles of exploitation of resources and the interpretation of the concept of "common heritage of mankind", which for many scientists to this day is amorphous and is sometimes interpreted differently in doctrine of public international law. Part of the literature, referring to international legal documents and the practice of states, indicates that the common heritage of mankind has the value of a principle, sometimes even *ius cogens*. On the other hand, some authors deny the legal nature of the institution of the common heritage of humanity, arguing that this mechanism is undefined and at best expresses certain political intentions on the international forum, and the Moon Agreement, which has been ratified only by a dozen or so countries, does not resolve these controversies[65].

In the world literature, one can also find a moderate view[66] that, despite numerous doubts related to the institution of the common heritage of mankind in space, high hopes can be pinned on the practice of applying this concept to the seas on the basis of the United Nations Convention on the Law of the Sea (UNCLOS), mainly through the International Seabed Authority (ISA) as the only international organisation mandated to control and regulate seabed activities in the international seabed area (the Area) for the benefit of mankind as a whole[67]. It is worth adding that the concept of the common heritage of mankind also appears in the UNSESCO Convention (Convention Concerning the Protection of the World Cultural and Natural Heritage), as well as in the preamble to the Antarctic Treaty of 1959, which refers to the progress and interest of all mankind, in the context of the peaceful use of the area and the freedom of research in Antarctica[68].

5. SUMMARY

As already mentioned, the extraction of natural resources from space in the near future will become a necessity for human presence in space. The legislative activities of the United States, Luxembourg and the United Arab Emirates have

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65 K. Lankosz, *Eksploracja i eksploatacja kosmosu. Czy Helium 3 zmieni status prawny przestrzeni kosmicznej?* (w:) E. Fonkowicz [ed.], Prawo międzynarodowe – teraźniejszość, perspektywy, dylematy. Księga Jubileuszowa Profesora Zdzisława Galickiego, wyd. WoltersKluwer, Warszawa 2013. p. 373.

66 E. Riedel, *Die Menschenrechte der dritten Dimension als Strategie zur Verwirklichung der politischen und sozialen Menschenreichte*, (Translation: Jerzy Zajadło in:) Ruch Prawniczy, Ekonomiczny i Socjologiczny, Rok LII – zeszyt 3-4, Warszawa 1990, p. 123-124.

67 UN Document: Contribution of the International Seabed Authority to the background note the General Assembly through its resolution 73/292 (https://www.un.org/sites/un2.un.org/files/isa.pdf – 15.08.2021).

68 Preamble to the Antarctic Treaty of 1959: „Recognizing that it is in the interest of all mankind that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord".

definitely gone beyond the discussion phase at the international level and are an expression of active interest in acquiring space resources, beside to the ongoing polemics about the status of commercial space exploitation under international law. It should be emphasized here, however, that the wide and enthusiastic adoption by the international community of the Outer Space Treaty in 1967 (129 signatory states, including 104 ratifications) made it possible to recognise the principles developed therein as norms of customary law in relation to states that did not sign the Treaty[69].

These principles include: the principle of non-appropriation of outer space (Article II of the Outer Space Treaty), the principle of the peaceful use of outer space (Article IV), the principle of mutual assistance (Article V) and the principle of state's responsibility for space activities (Articles VI and VII). Thus, these principles – as a source of law specified in Art. 38 of the Statute of the International Court of Justice (called there "the general principles of law recognized by civilized nations") – have also become binding for states that have not been bound by the Outer Space Treaty[70]. In turn, NASA under the "Artemis"[71] program argues that the extraction and use of space resources is fully acceptable under Art. II, VI and XI Outer Space Treaty[72].

This discrepancy between the activities of selected countries and international law is related to the lack of precise normative regulations at the international level, or the lack of their acceptance – as in the case of the Moon Agreement. The topic of legal loopholes is extremely rare in the literature on space law, and they even encourage actions in the spirit of the freedom of the cosmos, according to the idea of *Astra Liberum*. On the opposite side, however, is the interest of the commonalty. This naturally must create tensions between the divergent interests of individual consortia and states – and the global community[73].

Currently, on the basis of article I-IX of the Outer Space Treaty, it is possible to reconstruct such freedoms as: freedom of movement in outer space, freedom of research, freedom to construct installations for non-military purposes, freedom to

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69 M. Hofmannand, F. Bergamasco, *Space resources activities from the perspective of sustainability: legal aspects*, publ. Cambridge University Press, Cambridge 2020, https://www.cambridge.org/core (09.01.2021), p. 2.

70 See: B. Skardzińska, *Górnictwo kosmiczne – prawo i perspektywy* (in:) K. Myszona-Kostrzewa, E. Mreńca, P.B. Zientarski [ed.], *Prawne aspekty działalności kosmicznej*, publ. Kancelaria Senatu, Warszawa 2019, p. 170.

71 The Artemis program is implemented by the USA and serves the purpose of manned exploration of the Moon and other celestial bodies. See: https://aerospace.org/sites/default/files/2020-07/NSpC%20New%20Era%20for%20Space%2023Jul20.pdf (17.09.2021).

72 B. Malinowski, *Projekty pozyskiwania naturalnych surowców w kosmosie* (in:) M. Polkowska [ed.], *Współczesne trendy w polityce bezpieczeństwa kosmicznego*, publ. EuroPrawo, Warszawa 2020, p. 99.

73 L. Łukaszuk, *Współpraca i rywalizacja w przestrzeni kosmicznej. Prawo-Polityka-Gospodarka*, publ. TNOiK, Toruń 2012, p. 100.

extract resources (only for scientific purposes)[74]. The limitations of the above freedoms are in turn: prohibition of the appropriation of space along with celestial bodies (Art. II of the Outer Space Treaty), environmental protection (natural condition of outer space – Art. IX of the Outer Space Treaty), competition between entities exploring space (the need to indicate the limits of freedom that may violate the broadly understood freedom of other participants in commercial space exploration – Art. IX of the Outer Space Treaty)[75].

The strong position of the United States regarding the fact that the prohibition of space appropriation does not apply to private entities is to some extent hampered by the proposals of countries such as Belgium and Greece, which believe that without appropriate international legal regulations and international supervision, the exploitation of space resources will lead to the destruction of balance between states in outer space, which is a precondition for the peaceful coexistence of nations in space[76].

So where to look for detailed rules regarding the use of space resources? The answers should be sought on the oceans and their bottoms, which are also rich in natural resources and, like Open Space, have an extraterritorial character. The seabed outside the national jurisdiction belongs to the Common Heritage of Mankind, which means that this area cannot be appropriated, it should be used only for peaceful purposes, and the extraction of natural resources may only take place under the supervision of the International Seabed Authority (ISA), operating under the aegis of the United Nations. Therefore, it is difficult to ignore these analogies when looking for system solutions for the principles of the exploitation of space resources. Looking at the sea, you can see the horizon line, where the sea meets the sky, which prompts you to reflect on the formula: *per mare ad astra*.

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[74] Art. I Outer Space Treaty: „The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries".

[75] Also see: R. Wolfrum, *The Principle of the Common Herritage of Mankind* (in:) *Zeitschrift für ausländisches öffentliches Recht und Völkerrecht* 1983, vol. 43, p. 316.

[76] M. Hofmannand, F. Bergamasco, *Space resources activities from the perspective of sustainability: legal aspects*, publ. Cambridge University Press, Cambridge 2020, https://www.cambridge.org/core (09.10.2021), p. 2.

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THE CONCEPT OF GREEN, BLUE AND CIRCULAR ECONOMY

Abstract: The term „green economy" still does not have one universal definition accepted by scientists, practitioners, institutions, politicians, etc. Although the concept is widely discussed by members of international organizations, such as the UN or the EU, G20, governments, NGOs, local authorities, there are still a lot of misunderstandings around it, all the more so that new terms are created to name innovative ideas that have already been implemented or are in the phase of projecting, such as blue economy, sharing economy or circular economy. Economists are generally opposed to adding adjectives to the term „economy", stating that there is only economy, however the adjectives inform about what is the idea behind these terms. As the problem seems worth investigating, this was the reason for undertaking research in this field. One of the purposes of the article is to find the similarities and/or differences between these terms. The other purpose is tightly connected with the title of the paper and has to demonstrate that „greening" economic activities can foster innovativeness and stimulate economic development measured not only by using Gross Domestic Product as an indicator but also other measures like Human Development Index or well-being measures. The methods were based on study of literature and reports of international organizations and institutions. The findings showed that there are a lot of similarities between various terms naming environment-friendly sustainable development. Green economy should not be perceived as a cost or burden but more like a trigger factor for initiative and innovativeness.
The purpose of the article is to present the concepts of green, blue and circular economy as a new paradigm of economy, aiming to utilize limited natural resources in the most „economic" way. The overarching goal of this type of economic activity is to ensure socio-economic development, and not only economic growth, which was the basic measure of the achieved economic level of a given country for many years.
The method utilized in the article was based on comparative analysis of various sources dedicated to this topic, such as relevant literature, reports and elaborations of international organizations and institutions. The presentation of the results of conducting research was based on the descriptive method.

Conclusions resulting from the undertaken research lead to the statement that if we assume that the essence of economics is managing limited resources and allocating them to meet competitive goals, the green and blue economies are simply economics with particular regard to natural resources. On the other hand, the circular economy can be treated as an instrument for their protection and reuse of products. The implementation of the concepts of green, blue and circular economy, apart from a better utilization of scarce resources, can stimulate and foster innovativeness and create better conditions of life for human beings.

Key words: economic growth, green, blue and circular economy

INTRODUCTION

If you have put the windmill in your yard or some solar panels on your roof, bless your heart. But we will only green the world when we change the very nature of the electricity grid – moving it away from dirty coal or oil to clean coal and renewables. And that is a huge industrial project – much bigger than anyone has told you. Finally, similarly to the New Deal, if we undertake the green version, it has the potential to create a whole new clean power industry to spur our economy into the 21st century[1]. In 1972 The Club of Rome published its very famous report titled „The Limits to Growth"[2]. The conclusion of this report was that if nothing is done then the humanity will experience catastrophe in 100 years. The rapidly growing World's population resulting in scarcities of many natural resources causes that the problem of their depletion becomes very dangerous for humanity. This situation creates a strong impetus for developing new concepts, ideas, solutions and also influences the ways of thinking about economy and economic processes and the methods of measuring the results of human economic activity. Traditionally used measure for economic situation was Gross Domestic Product but it appeared that in the era of extensive utilization of resources, pollution and environment degradation this indicator is not sufficient. Green economy, blue economy and circular economy are the answers for emerging threats and challenges the humanity faces. The transition to the new model or models of economy – from linear to circular becomes a must. However, it is still the problem of the rational use of resources, in particular the scarce and limited ones. Economy, whether it is named green, blue or circular, deals with resources and efficient use of them. The purpose of the article is to present various approaches to the essence of economy, economic growth and development as well as the concepts of green, blue and circular economy.

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1 T. L. Friedman, *Opinion – A Warning From the garden,* „The New York Times", 2007, January 19.

2 Meadows D. H., Meadows D. L., Randers J., Behrens III W. W., *Granice Wzrostu,* PWE, Warszawa 1973.

DEFINITIONS OF ECONOMY

Economy is the science about economic processes and economists try to detect and describe these processes. There are various resources which are subject to economic processes:

- human – people, their knowledge, practical skills, experience,
- natural resources – soil, land with its natural resources, water and air[3],
- resources resulting from human activity – tools, machines, buildings, semi-finished products, means of transport, financial resources, etc[4].

There are not enough resources to meet all human needs, except the air. Managing limited resources is becoming a challenge for the all mankind in the situation when global population is rapidly growing[5]. Another definition describes economy as a large set of inter-related production and consumption activities that play an important role in determining how scarce resources are allocated. The production and consumption of goods and services are used to meet the needs of people living and working within the economy, which is also referred to as an economic system. Economics deals in particular with those means of satisfying human needs that are obtained through the extraction, processing and relocation of natural resources. The result of such activities are products. In addition to products, there are the so-called free goods that are not the result of production and occur in nature in a form suitable for the direct meeting human needs, e.g. water. In practice, the resources of this type of goods are running out. Therefore, there is a need for their rational use and wider interest in economic science[6].

G. S. Becker defines economy as „the study of the allocation of scarce means to satisfy competing ends. Air is not usually scarce, and ordinarily there is no economic problem in the use of air since nothing else must be forfeited"[7].The

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[3] Natural resources are often named natural capital that is defined "as the world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this natural capital that humans derive a wide range of services, often called ecosystem services, which make human life possible. The most obvious ecosystem services include the food we eat, the water we drink and the plant materials we use for fuel, building materials and medicines. There are also many less visible ecosystem services such as the climate regulation and natural flood defenses provided by forests, the billions of tonnes of carbon stored by peatlands, or the pollination of crops by insects. Even less visible are cultural ecosystem services such as the inspiration we take from wildlife and the natural environment", *What is natural capital*, https://naturalcapitalforum.com/about/ [access 31.07.2019]

[4] R. Milewski, E. Kwiatkowski, *Podstawy ekonomii*, eds. R. Milewski, i E. Kwiatkowski, Wydawnictwo PWN, Warszawa 2018, p. 23

[5] According to the medium variant of prognosis of UN there will be 9,7 billion people living in our planet, *World Population Prospects 2019,* United Nations, Department of Economic and Social Affairs, Population Division (2019). Online Edition. Rev. 1.

[6] *Podstawy ekonomii*, *op. cit*., p. 27.

[7] G. S. Becker, *Economic Theory*, Transactions Publishers, London 2011, p. 1.

corresponding definition says that economy is a field of science that explores how society uses its limited resources to best meet its needs. Resources scarcity is the most significant barrier to meeting human needs and during the whole history of mankind it was the main reason of countless destructive wars, conflicts and migrations[8].

ECONOMIC GROWTH AND DEVELOPMENT

In many non-economic publications these two terms are treated as the same and used interchangeably, however there are basic differences between them and it is important to explain and to understand them, because the term „economic development" has a lot of similarities with the concept of green economy. Economic growth can be described as an increase in the production of products (goods and services) compared from one period of time to another. It can be measured in nominal or real terms. Measure of real growth takes into account inflation. The higher level of inflation rates the lower level of real economic growth is. Traditionally, aggregate economic growth is measured in terms of gross domestic product – GDP. It is the most popular and extensively used indicator of the economic situation a certain country, continent or the whole world. However, there are some imperfections inherent in it – the GDP does not take into account the costs of environmental pollution resulting in premature deaths, diseases and deteriorating living conditions.

Economic development is concentrated on both sides of the economy of a certain country – qualitative and quantitative. It takes into account such factors as healthcare system and access to it, including medical facilities, purchasing power per capita, quality of housing, increase of employment opportunities, conservation of the environment, access to drinking water, sanitation systems, education and spread of it, literacy rate, eradication of poverty, sustainable and balanced transport network[9], etc. Having broader point of view on the economy of a certain country, it is easier to assess its economic situation and in particular the level of well-being of citizens, however there are also other, non-material factors affecting satisfaction with life.

Being aware of imperfections of GDP as a measure of the economic situation in a particular country, Mahbub ul Haq, a Pakistani economist living and wor-

[8] The number of international migrants reaches 272 million in 2019, it has increased of 51 million since 2010. Currently international migrants comprises 3,5 per cent of the global population, *The number of international migrants teaches 272 million in 2019, continuing an upward trend in all world regions,* September 17, 2019, https://www.un.org/development/desa [access 17.09.2019].

[9] The problem of sustainable transport development is presented in the publication written by B. Pawłowska, *Zrównoważony rozwój transportu na tle współczesnych procesów społeczno-gospodarczych*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2013.

king in Great Britain, proposed a new aggregate indicator in 1990. It measures not only GDP but also comprises human aspects such as life expectancy, education and gross national product *per capita*. Later it was adopted by United Nations Development Programme to measure countries' level of development. The indicator is named Human Development Index but, although it better illustrates the level of development of a certain country, it does not measure pollution or environment degradation.

Many economists are aware of the imperfections and shortcomings of the GDP as a measure of economic growth and suggest developing a new indicator, better illustrating the real level of achieved development, in particular focused on environmental aspects of human life. In 2018 OECD published a report prepared by the High-Level Group on Measurement of Economic Performance and Social Progress led by J. E. Stiglitz, J. P. Fitoussi and M. Durand, presenting the results of the project focused on developing and improving GDP as an indicator of economic growth. It is worth quoting one of the paragraphs from this report: „We need to move „Beyond GDP" when assessing a country's health, and complement GDP with a broader dashboard of indicators that would reflect the distribution of well-being in a society and its sustainability across its social, economic and environmental dimensions. The challenge is to make the dashboard small enough to be easily comprehensible, but large enough to summarize what we care about the most[10]".

DEFINITIONS OF GREEN ECONOMY

There are several definitions of green economy and some of them are worth presenting. The most widely used and popular is the definition proposed by the United Nations Environment Programme (UNEP)[11] where the concept of green economy is described as follows: „a green economy can be perceived as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive[12]". There are many similarities to the concept of economic development presented above, except that the green economy definition strongly emphasizes ecological aspects. The essence of a green economy lies in growth in income and level of employment driven by both public and private investments,

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10 J. E. Stiglitz, J. P. Fitoussi, M. Durand, *Beyond GDP. Measuring What Counts for Economic and Social Performance*, OECD Publishing, Paris 2018, p. 13.

11 The United Nations Programme for Environment was established by United Nations Conference on the Human Environment in Stockholm in 1972.

12 *Green Economy – Introduction. Setting the stage for a green economy transition,* https://whygreeneconomy.org/information/unep-green-economy-report [access 30.04.2019] see also: L. R. Kahle, E. Gurel-Atay, Eds, *Communicating Sustainability for the Green Economy*, M.E. Sharpe, New York 2014.

focused on reduction of carbon emissions and pollution of environment. They should enhance efficient usage of energy and other resources, protect biodiversity and ecosystems. It is necessary to accelerate such investments by special policy reforms, supported by instruments ranging from changes in law, through public expenditure, to tax breaks, etc. Natural capital is not boundless and must be perceived as a critical economic asset which should be protected, rebuild if necessary and possible and left for the next generations. In the Green Economy Report, published by the UNEP in 2011, it is a statement that „to be green, an economy must not only be efficient, but also fair. Fairness implies recognizing global and country level equity dimensions, particularly in assuring a just transition to an economy that is low-carbon, resource efficient, and socially inclusive[13]". Economic growth, environmental responsibility and social development are fundamental elements included in International Chamber of Commerce definition saying that green economy is „an economy in which economic growth and environmental responsibility work together in a mutually reinforcing fashion while supporting progress on social development[14]".

Green Economy Coalition's definition describes green economy as „a resilient economy that provides a better quality of life for all within the ecological limits of the planet[15]". Finally, it is worth presenting the definition of the Danish 92 Group[16], because it highlights various aspects of green economy, that „it is not state but a process of transformation and a constant dynamic progression. The green economy does away with the systematic distortions and dysfunctionalities of the current mainstream economy and results in human well-being and equitable access to opportunity of all people, while safeguarding environmental and economic integrity in order to remain within the planet's finite carrying capacity. The economy cannot be green without being equitable[17]". First of all, it must be emphasized that the term has a dynamic character and it has to be stressed that it is consistent with the Nordic countries value system in which human coexistence with the natural environment plays a major role.

Green economy refers to sectors (e.g. energy), topics (e.g. pollution), principles (e.g. polluter pays) or policies (e.g. economic instruments). It can also desc-

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13 UNEP Report, *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication,* 2011, www.unep.org/greeneconomy [access 30.04.2019].

14 C. Allen, S. Clouth, *A Guidebook to the Green Economy, Issue 1: Green Economy, Green Growth, and Low-Carbon Development – history, definitions and a guide to recent publications,* UN Division for Sustainable Development, UN Department of Economic and Social Affairs, New York 2012, p. 63, http://uncsd2012.org/content/documents/528GreenEconomyGuidebook_100912_FINAL.pdf [access 1.05.2019].

15 *Ibidem.*

16 The Danish 92 Group is a coalition of 23 Danish NGO's working on issues related to the environment and development. The group was established in 1991 with the mandate of coordinating the Danish NGOs' preparations for the United Nation's Conference on Environment and Development (UNCED) in Rio de Janeiro, in 1992.

17 C. Allen, S. Clouth, *op. cit.*, p. 63.

ribe an underpinning strategy, such as the mainstreaming of environmental policies or a supportive economic structure. Resource efficiency is a closely related concept, since the transition to a green economy depends on meeting the twin challenges of maintaining the structure and functions of ecosystems and finding ways to cut resource use in production and consumption activities and their environmental impacts. It is important to integrate economic and environmental policies and create opportunities for new sources of economic growth and avoid unsustainable pressure on the quality and quantity of the natural capital. It is necessary to employ a set of economic and legal tools such as a relevant tax system and regulations, subsidy and trading systems. A noteworthy case of appreciating the importance of the green economy may be the first world's magazine devoted to these issues, which is being published in South Africa, entitled „Green Economy Journal".

BLUE ECONOMY

The definitions of blue economy are similar to green economy but they are more specific and relate to oceans, seas and coastal areas. Although the term is newer than the term „green economy", it is sufficiently defined, which is reflected in a relatively large number of attempts at explaining the term. A brief review of selected definitions proves that the essence of them is very similar to the definitions of „green economy". The definition proposed by the World Bank says that „sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem[18]".

In the 2018 Annual Economic Report on EU Blue Economy it is described as „all economic activities related to oceans, seas and coasts. It covers a wide range of interlinked established and emerging sectors[19]". It is emphasized that Blue Economy should be treated as „a vital component of Europe's coastal economies[20]" because oceans contribute to overall prosperity and wellbeing of the European societies. Blue Economy can enhance innovativeness, create investment, and new work places, and in consequences contribute to economic and social development.

The Centre for the Blue Economy defines blue economy as follows: „it is now the widely used term around the world with three related but distinct meanings – the overall contribution to the ocean economics, the need to address the environmental and ecological sustainability of the oceans, and the ocean economy as a growth opportunity for both developed and developing countries[21]". In yet

18 *What is the Blue economy?,* The World Bank, 6 June, 2017.

19 *The 2018 Annual Economic report on EU Blue Economy,* EU, 2018, p. i.

20 *Ibidem.*

21 *Our History and Methodology,* Middlebury Institute of International Studies at Monterey https://www.middlebury.edu/institute/academics/centers-initiatives/center-blue-economy/about/history [access 2.05.2019].

another definition it is stated that „blue economy also includes economic benefits that may be not marked, such as carbon storage, coastal protection, cultural values and biodiversity[22]".

The World Wild Fund begins its report headed „Principles for a Sustainable Blue Economy" with two senses given to this term: „For some blue economy means the use of the sea and its resources for sustainable economic development. For others, it simply refers to any economic activity in the maritime sector whether sustainable or not[23]". A sustainable blue economy „must respect ecosystem integrity, and that the only secure pathway to long-term prosperity is through the development of a circular economy[24]".

CIRCULAR ECONOMY

Circular economy is a new economic model supporting implementation of the green and blue economy concepts. The model is based on the assumption that the value of products, materials and resources should be maintain in the economy as long as possible. The purpose is to reduce waste to a minimum. In particular raw materials need to be repeatedly recycled in more than one industry. The concept of product life cycle is not relevant any more to circular economy – products should be used many times as a result of various economic processes. The concept of linear economy is based on the following cycle: raw materials acquisition – production – use – waste utilization and due to EU recommendations should be gradually replaced by the circular economy: production – use – use of waste as raw materials in the next production cycle, and so on.

It is worth saying that the European Union's priority is to implement the new principles of the ecological policy protecting limited resources as the answers to green and blue economy demands. The plan takes into account a very wide range of legislative proposals that aim to reduce food waste, develop quality standards for secondary raw materials. It also includes a strategy on plastics that addresses issues related to their recycling. The circular economy package contains proposals for setting new waste management goals, which should be achieved by 2030. The target is to significantly increase the level of waste recycling. According to the European Commission, some sectors face serious challenges in the context of the circular economy that result from the characteristics of their products and value chains, their environmental footprint, and often dependence on non-European

[22] S. Bertazzo, *What on Earth is the „Blue economy"?* Human Nature Conservation International, https://www.conservation.org [access 2.05.2019].

[23] *Principles for a Sustainable Blue Economy,* http://wwf.panda.org/our_work/oceans/publications/sustainable_blue_economy_reports.cfm [access 2.05.2019].

[24] *Ibidem*.

materials. As a result, in the circular economy package there are five areas requiring a special approach: plastics, food waste, critical raw materials, construction and demolition waste, biomass and bioproducts.

CONCLUSIONS

Limited natural resources and inappropriate system of their utilization together with the rapid population growth make a significant threat for the future of the mankind. Awareness in this respect was an incentive to begin discussions about the need to change the economic paradigm. It is necessary to take care of the environment and to efficiently use all resources, in particular the scarce ones. The concepts of green and blue economy, circular and sharing economy have to show that at the centre of global attention are the solutions to the most serious problem that humanity is dealing with. It is necessary to rethink the existing paradigms of the economy and introduce new ones as the answer to contemporary and future challenges our planet faces.

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INNOVATIVE SECURITY STRATEGIES FOR THE PORT OF GDYNIA INFRASTRUCTURE

Abstract: The Port of Gdynia is an operator of critical infrastructure. It is also a dual-purpose port, where the specificity of a merchant and naval port interpermeate. This fact is a challenge in the area of port security, the level of which depends, among others, on the implementation of the Comprehensive Drone System (pol. Kompletny System Dronowy, KSD). The authors of the article present the conclusion that the key to the success of the adopted port security strategy is the integration of all KSD component systems: DTM, LSM and Antydron in one solution and the launch of the local ICT infrastructure under CEDD. It is important here to integrate the solution with the U-space foundation, the central PANSA UTM system. The implementation of KSD also perfectly fits into the framework of the smart port concept and has great development potential, which spans over several decades to come. Therefore, the article presents a number of recommendations regarding the implementation of KSD and further implementation of the smart port concept.

Keywords: Smart Port, Port of Gdynia, KSD, PANSA, UTM, DTM, LSM, Antydron, BSP, drone, U-space, CEDD, cybersecurity, automation.

INTRODUCTION

On March 5, 2020, in the port of Gdynia a grain granary with a storage area of 7000 m^2 (235×30×15), which was located in an area leased by the Baltic Grain Terminal, almost completely burned down. The fire broke out before 9 o'clock and 30 fire crews were dispatched to extinguish it. The port guard and the largest ship of the Maritime Search and Rescue Service – MS Kapitan Poinc, also joined the firefighting operation. The warehouse was filled in one tenth with the goods: soybean and grain. There were no people in the facility at the time of the fire, so, luckily, no one was injured. However, there was a risk of the fire spreading over

adjacent gas storage facilities, two tent halls and the halls of a shipbuilding company constructing yachts. Fortunately, thanks to a smooth operation, firefighters managed to stop the fire. About two weeks after the fire was extinguished, workers noticed smoke coming out of the burned warehouse again. The port dispatcher and the fire brigade were immediately informed. Perhaps the threat could have been detected earlier or neutralised with fewer forces and resources had the security of Gdynia port been supervised by *drones*[1]. Some sensitive loads, such as vegetable oils, cereals, feed, nut shells, or wood chips, which are stored in the port of Gdynia, require constant inspection. In the event of local temperature increase, thermal camera drones could immediately notify the relevant services, operating in 24/7 mode under safe weather conditions.

In September 2019, seven cruise missiles and a swarm of 18 long-range drones with suspended explosives forced their way through Saudi Arabia's advanced air defense systems, destroying the world's largest refinery in Abqaiq and Khurais and the processing installations there. This event has had a huge global impact. Yemeni rebels from the Houthi movement have taken responsibility for this precise attack, which halved Saudi Arabia's oil and gas production and increased prices of these raw materials on the global market[2]. The report presented at the UN Security Council meeting identified many similarities between the drones used in the attack and Iran's IRN-05 unmanned aircraft[3].

These two events described above are just some examples of extremely different incidents – the contrast between them highlights the potential of drone technologies, both in the area of support for critical infrastructure security systems and new potential threats that involve a previously unidentified risk of large-scale use of Unmanned Aerial Vehicles (in short: UAV).

In order to face today's challenges in the area of critical infrastructure security, in April 2019, during the conference "Security of critical infrastructure and mass events in the era of technological breakthrough of the 21st century" („*Bezpieczeństwo infrastruktury krytycznej oraz imprez masowych w dobie przełomu technologicznego XXI w.*"), the Port of Gdynia Authority S.A. (*Zarząd Morskiego Portu Gdynia S.A.*, ZMPG) announced plans to implement an innovative, comprehensive drone system (*kompletny system dronowy* – KSD), and at the end of 2019 signed a letter of intent with Pelixar S.A. from the Pomeranian Science and Technology Park (*Pomorski Park Naukowo-Technologiczny* – PPNT) for the im-

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1 *Pożar w Porcie Gdynia. Niemal doszczętnie spłonął spichlerz zbożowy, https://gdansk.tvp.pl/46987346/pozar-w-porcie-gdynia-niemal-doszczetnie-splonal-spichlerz-zbozowy*, [access: 28.06.2020].

2 In an interview with Der Spiegel, Mohamed Ali al – Houthi claims that the Houthis are in possession of drones: Samad – 1, Samad – 2, Samad – 3 and Qasef – 1 (according to their data with a range of 1500 km.). Vide: „Forum" 21/2019, p. 27; N. Sharkey, *Broń autonomiczna*, „Świat Nauki", 2020, nr 4 (344), p. 38.

3 H. Pamuk, *U. S. probe of Saudi oil attack shows it came from north – report*, https://www.reuters.com/article/us-saudi-aramco-attacks-iran-exclusive/exlusive-u-s-probe-of-saudi-oil-attack-shows-it-came-from-north-report-idUSKBN1YN299, [access: 28.06.2020].

plementation of the Aviation Monitoring System (pol. *Lotniczy System Monitoringu* – LMS)[4]. Those are the elements of the Gdynia port infrastructure security strategy that this study is devoted to.

SHORT CHARACTERISTICS OF UNMANNED AERIAL VEHICLES

UAVs are piloted remotely (are not autonomous) by operators or have autonomy (limited or total). For this reason, the abbreviation UAV is sometimes developed as "Unmanned Aerial Systems" (UAS). Fully autonomous drones are also considered as a component of Autonomous Weapons Systems (AWS) and – as many researchers point out – are likely to participate in hostilities today[5]. The armed versions of the UAVs, intended for combat operations, are referred as the Unmanned Combat Air Vehicles (UCAV)[6]. The degree of autonomy or control of the UAV by the human (operator) can be determined according to the following scale, relating to the location of the operator in the so-called control loop:[7]

- Human in the loop – the operator remotely controlling UAV (or other device, e.g. a robot) fully retains control over its actions.
- Human on the loop – UAV has a high degree of autonomy, moves independently and searches for goals. In the case of UCAV, it attempts to attack the target, but the operator must authorise this decision.
- Human out of the loop – fully autonomous UAV (or any other device, e.g. robot, UCAV, etc.).

UAVs are very diverse not only in terms of degree of autonomy, but also in size, weight or construction (vide: Fig. 1). We distinguish here[8]:

1. Single rotor, Multi-rotor drones – i.e. rotorcrafts with rotors in essentially vertical axes (e.g. Black Hornet Nano, 10×2.5 cm);
2. Fixed Wing drones – aerodynes[9] with fixed load-bearing surfaces (e.g. Chinese Feihong-98 in size Antonov AN-2 aircraft[10]).

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4 *Port Gdynia w nowej erze bezpieczeństwa – list intencyjny pomiędzy Zarządem Morskiego Portu Gdynia S.A., a firmą Pelixar S.A.*, https://oficynamorska.pl/2019/port-gdynia-w-nowej-erze-bezpieczenstwa-list-intencyjny-pomiedzy-zarzadem-morskiego-portu-gdynia-s-a-a-firma-pelixar-s-a/, [access: 28.06.2020].

5 N. Sharkey, *Broń*.

6 P. Polko, R. Polko, *It was safe already*, Gliwice2018, p. 56.

7 *Ibidem*, p. 60.

8 Vide: P. Burdziakowski, *Groźne platformy*, „Przegląd Sił Zbrojnych", 2017, nr 4, pp. 120-127.

9 *Aerodyne* (gr. *a r* – air, gr. *dýna(mis)* – force) – an aircraft heavier than air, floating in the atmosphere as a result of air exposure to its supporting surfaces. Based on: *Aerodyna*, https://encyklopedia.pwn.pl/haslo/aerodyna;3866014.html, [access: 28.06.2020].

10 It is worth noting that the airframe Antonov AN-2, which became the basis for the construction of the Feihong-98, was flown already in 1947. The Chinese version of Antonov AN-2 is known as Yun-5.

Contrary to stereotypical opinions, most drones do not carry combat payloads and are used only for the collection of intelligence. Therefore the solutions designed for the military are so willingly used by other formations and institutions dealing with e.g. monitoring of national borders, search for missing persons, emergency rescue, observation of weather changes, spread of natural disasters or, precisely, monitoring the condition and ensuring the safety of critical infrastructure. Consequently UAVs are widely used not only in the military but also in the civilian sector, including applications such as recreation, business and industry[11].

Fig. 1. On the left, the Black Hornet Nano combat drone (photo: Corporal Daniel Wiepen/MOD); on the right, transport drone Feihong-98. You can see the difference in size, weight, construction and purpose of UAVs[12].

It is worth recalling the PrimeAir initiative implemented by Amazon, which (for the first time in 2013) presented the concept of delivery drones – allowing to deliver the shipment to the customer's place of residence of their own e--commerce platform. The development of this concept continues to this day and still requires overcoming a number of technological and legal challenges related to inter alia air traffic safety[13]. In 2017, the Civil Aviation Authority of Israel (CAAI) has given Israeli startup Airobotics a permission for commercial and completely autonomous flights in Israel[14].

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11 P. Polko, R. Polko, *Bezpiecznie…*, p. 56.

12 Own study based on: (1) A. Pawłowski, US Army zamówiła miniśmigłowce Black Hornet Nano, https://www.konflikty.pl/aktualnosci/wiadomosci/us-army-minismiglowce-black-hornet-nano/, [access: 28.06.2020]; (2) SF Express, the express delivery giant in China, showcases its unmanned aerial vehicle. The UAV is called FH98, which is based on a retired Yun-5, https://twitter.com/ChinaAvReview/status/1052013620920377344/photo/3, [access: 28.06.2020].

13 M. Zawadzak, *Nowe drony Amazon PrimeAir robią wrażenie!*, http://www.swiatdronow.pl/nowe-drony-amazon-primeair-robia-wrazenie, [access: 28.06.2020].

14 L. Kolodny, *Airobotics scores authorization to fly autonomous drones in Israel*, https://techcrunch.com/2017/03/27/airobotics-scores-authorization-to-fly-autonomous-drones-in-israel/, [access: 28.06.2020].

The potential of the UAVs and the entire market associated with this technology can be demonstrated by the following figures:[15]

- 73.5 billion USD – the value of the global civilian drone market for 2017–2026;
- 20.7 billion USD – the value of the European civilian drone market in 2017–2026;
- 3.26 billion PLN – the value of the Polish civilian drone market in 2017–2026;
- 100,000 – the number of drones in Polish airspace.

All these features present a challenge of integrating drone technologies into the economy nowadays. This requires action in the area of regulation, technical infrastructure, as well as the development of products and services that will benefit from the availability of airspace. It is estimated that the value of integrating drones into the economy, i.e. the indirect benefits that the economy as a whole can bring, is significantly higher than the value of the drone market itself, calculated as the value of the equipment produced[16]. The key issue here is the development of the U-space environment, which will open up a whole new market for technology and services. The initial value of this market estimated over the period of 10 years includes 310 billion PLN according to a pessimistic scenario, 576 billion PLN according to a moderate scenario, and based on the assumptions of an optimistic scenario up to 913 billion PLN in economic benefits[17].

U-SPACE CONCEPT

U-space is a widely accepted term in the European Union covering all aspects of UAVs integration into the economy. Poland has been actively involved in the creation of this concept and is now one of the leading Member States in its development. This term is not used outside the European Union[18]. The main pillars of the U-space are shown in Fig. 2.

The gradual development of the U-space environment, with the technological development of UAVs, including system elements to improve UAVs' flight management and legislation, will involve the use of drones in areas where they have not yet been used at all or to a small extent. Commercial use of UAVs will become increasingly common in industry, agriculture, infrastructure investment and construction[19], as well as in the wider sense of emergency rescue and security. Drones

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15 *Biała Księga Rynku Bezzałogowych Statków Powietrznych. U-Space – Rynek – Wizja Rozwoju*, red. M. Witeska i J. Nowak, Warszawa 2019, p. 4.
16 *Ibidem*, p. 5.
17 *Ibidem*.
18 *Ibidem*, p. 10.
19 *Ibidem*, p. 29.

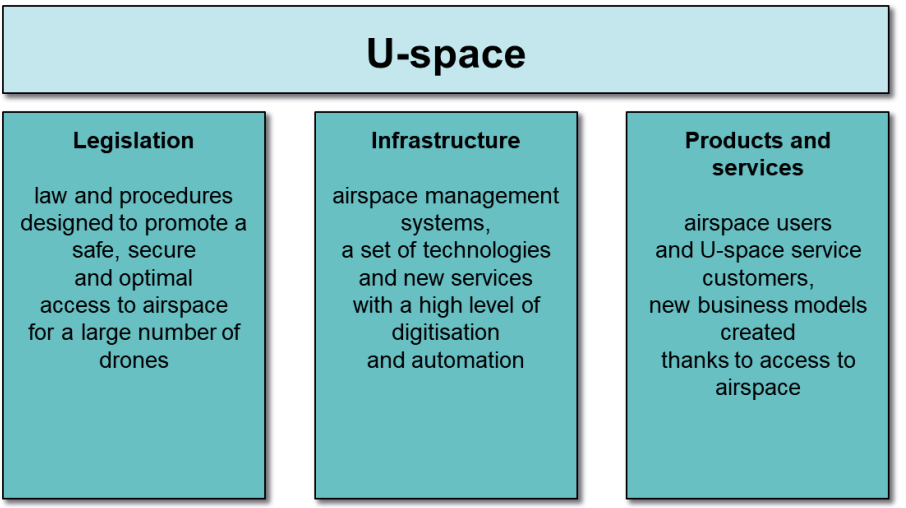

Fig. 2. Three pillars of U-space[20].

will also increasingly appear in cities, which entails the need to define new rules and involve local authorities in the process of managing access to airspace. Large--scale drone operations will require investment in ground infrastructure and the detailed organisation of UAV flights in urban areas, which may even lead to changes in the urban layout[21]. This poses a major challenge, which is also faced by the ZMPG, deciding to implement an innovative security strategy, which contains the UAV component, for the Port of Gdynia infrastructure. In general, U-space can be defined as: *infrastructure for the UAVs, which is to enable collision-free, integrated drone operations in airspace in the future, in particular commercial, economic and state operations*[22]. U-space is an ecosystem that is gradually being developed, in line with the development of technologies that enable increasingly automated processes and autonomous drone operations[23].

ON THE WAY TO THE COMPLEMENTARY DRONE SYSTEM OF THE PORT OF GDYNIA

Poland's unique position in the global drone market is mainly due to user--friendly legislation, the rapid development of unmanned technologies and the largest number of UAVO-qualified operators after the USA and Japan[24]. Between

[20] Own study based on: *Biała Księga Rynku Bezzałogowych Statków Powietrznych. U-Space – Rynek – Wizja Rozwoju*, pod. red. M. Witeska i J. Nowak, Warszawa 2019.
[21] brak przypisu
[22] Vide: *U-Space*, http://cedd.pl/start/jak-dziala-cedd/, [access: 28.06.2020].
[23] *Ibidem.*
[24] (1) UAVO – *Unmanned Aerial Vehicle Operator*; (2) *Port Gdynia w Nowej erze.*

2013 and 2018, the Civil Aviation Authority (pol. *Urząd Lotnictwa Cywilnego*, ULC) issued almost 10,000 UAVO certificates of qualification. During the same period, only 72 incidents involving drones were reported[25].

The greatest asset of Poland, however, is the Central European Drone Demonstrator (CEDD), a program whose task is to create recommendations and procedures for future legislative processes and implement the U-space concept in the country. CEDD has dedicated DroneLabs, task force cells that focus on specific sectors such as U-Space, transport, environment, energy and security. According to the agreement of September 30, 2019, Port of Gdynia became the owner of Security DroneLab, one of the most promising and interesting sectors of CEDD[26].

The Port of Gdynia is of significant geostrategic importance for the country, it is the operator of the Polish critical infrastructure. It is a dual-purpose seaport in which the specificity of a commercial and war port permeates, and both civilian and military infrastructure are present here. The port operates under NATO's HNS programme[27], hosting the North Atlantic Alliance's military force. There are also business entities interested in a high level of security in connection with their business activities and trade secrets[28]. This is a particular challenge in the area of port security, the level of which will depend on – inter alia – the implementation of the Comprehensive Drone System (KSD) of the Port of Gdynia, in the assumptions consisting of the following systems[29]:

- DTM (*Drone Traffic Management*) – a system for managing UAVs' flights over the Port of Gdynia;
- „AntyDron" – a control system dedicated to the detection in the airspace, identification and neutralisation of unauthorised drones;
- LSM (pol. *Lotniczy System Monitoringu* – Aviation Monitoring System) – a system using unmanned aerial vehicles to identify and verify security and crisis events.

Fig. 3 shows a high-level vision of KSD IT architecture for Port of Gdynia.

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25 *Biała Księga…*, p. 41.

26 *Port Gdynia w nowej erze….*

27 Poland, as a member of the North Atlantic Treaty Organisation (NATO), has been obliged to respect allied commitments. One of them is to support allied forces coming to our country, as host nation, under Host Nation Support (HNS) system. The proper implementation of Poland's support is crucial for the defence of our country, along with its credibility as a partner of allied troops. Vide: S. Łazarek, *Polska jako państwo-gospodarz w ramach systemu HNS*, https://rcb.gov.pl/polska-jako-panstwo-gospodarz-w-ramach-systemu-hns/, [access: 28.06.2020].

28 Vide: (1) T. Jurczak, *Port w Gdyni planuje wykorzystać drony do wsparcia monitoringu, bezpieczeństwa ludzi i analizy zanieczyszczeń*, https://www.sztucznainteligencja.org.pl/nad-portem-gdynia-beda-czuwac-drony/, [access: 28.06.2020]; (2) *Port Gdynia w nowej erze….*

29 *Port Gdynia w nowej erze….*

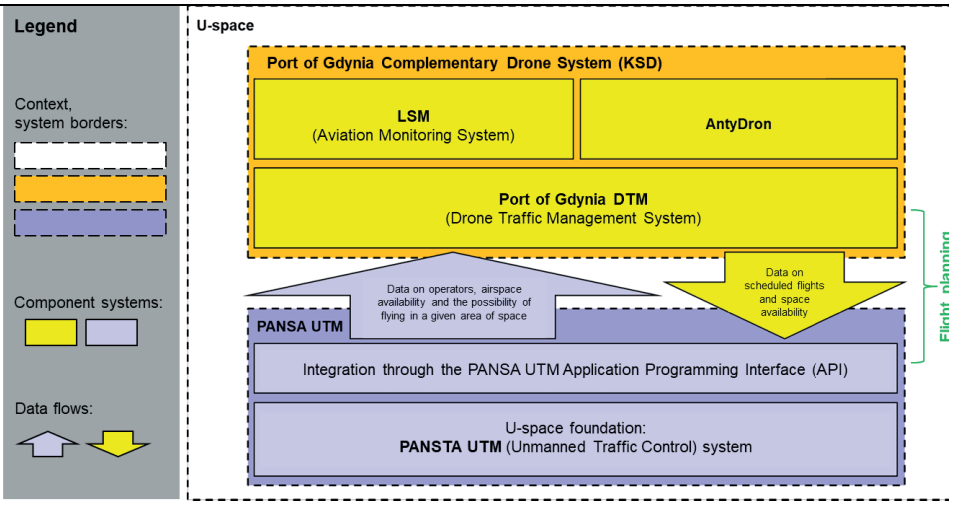

Fig. 3. High-level vision of KSD IT architecture for Port of Gdynia

OWN STUDY

Key to KSD's operation is integration with the U-space foundation, the PANSA (Polish Air Navigation Services Agency – pol. *Polish Air Navigation Agency*, PAŻP) UTM system (Unmanned Traffic Control), which is a central system for coordinating and managing drone traffic, operated by PAŻP. Thanks to integration through the appropriate protocols and usage of the API (Application Programming Interface), PANSA UTM can exchange data with vendor-based on-premises DTM systems that operate across the country – e.g. Port of Gdynia DTM. On the other hand, the Port of Gdynia DTM system acts as a local UTM system and is intended to support the management of UAVs flights over the port area[30]. The data exchanged between PANSA UTM and Port of Gdynia DTM systems are necessary in the UAVs flight planning process – the exchanged data scope is as follows:

- From Port of Gdynia DTM system to PANSA UTM system – data on planned flights and availability of airspace of the Port of Gdynia.
- From PANSA UTM system to Port of Gdynia DTM system – data on operators, space availability and the possibility of flight in the airspace of the port.

In addition to the Port of Gdynia DTM, under KSD also LSM and AntyDron systems are being operated. The first, LSM, supports the implementation of – inter alia – such tasks as:

- environmental monitoring of water and air,

[30] At the time of writing, the Port of Gdynia DTM system tests were in progress.

- control of technical infrastructure,
- monitoring of security threats,
- verification of emergency calls,
- monitoring of bulk material depots,
- operational support during protests (e.g. environmentalists),
- support for Search&Rescue (SAR) operations within the port's administrative precinct,
- operational support in the event of environmental contamination,
- the supply of emergency or medical supplies between the port and the ship.

The second system, AntyDron, is responsible for:

- detection and identification of unmanned aerial vehicles,
- interfering and neutralising the work of the UAVs,
- forcing UAVs to land,
- preventing foreign drones from entering port's airspace,
- tracking of flying objects that have breached the port airspace.

All KSD component systems, i.e. local DTM system (ensuring integration with the central PANSA UTM system), LSM and AntyDron should eventually be integrated for maximum usability of the solution. A system deployment project of this complexity requires a step-by-step approach and multiple tests, so it is expected that KSD will gradually achieve its full functionality. Here appears, inter alia, a number of challenges in the area of cybersecurity, and the system itself has a high potential for development, which can be placed in the perspective of a dozen years or even decades. It is worth emphasizing that KSD fits perfectly into the smart port concept, which involves the use of not only air drones, but also water (marine) drones[31], e.g. in the area of port security.

INNOVATIONS IMPLEMENTED BY PORTS. SMART PORT CONCEPT

According to *Port Cybersecurity*[32] report by European Union Network and Information Security Agency (ENISA), it is recommended that ports develop their own cybersecurity and infrastructure, as well as data protection. The general trend towards digitalization obliges ports to meet new technological directions, while the smart port[33] concept aims to innovate and increase port security. The necessary premise of this approach, given the high competitiveness of ports, is to

[31] Water drones (aquatic drones); marine drones (sea drones).

[32] *PORT CYBERSECURITY. Good practices for cybersecurity in the maritime sector*, https://www.enisa.europa.eu/publications/port-cybersecurity-good-practices-for-cybersecurity-in-the-maritime-sector, [access: 28.06.2020].

[33] Koncepcja smart port według Yann Alix. Vide: *What is a smart port?*, http://parisinnovationreview.com/articles-en/what-is-a-smart-port, [access: 28.06.2020].

implement technologies from the areas of artificial intelligence, big data analysis[34], blockchain[35], cloud computing[36] or the Internet of Things[37].

The smart port concept involves integration of seaport security systems, as well as automation of port equipment and processes. In the context of this type of integration, the potential of KSD of the Port of Gdynia, which can be part of a long-term development strategy in line with the smart port concept, is revealed. It should be noted that one of the key challenges facing modern seaports is the increase in competitiveness and efficiency of transshipment operations. However, these objectives cannot be achieved at the expense of security. The introduction of autonomous transshipment facilities will minimise the risk of accidents. It will also significantly increase the efficiency of handling processes by making the most of the equipment's uptime. In order to improve port operations, it is advisable to use aerial and water (marine) drones[38]. Drones are used in places where other technical solutions cannot be used, e.g. in the case of structures that are difficult to reach for humans or specialised machinery and, in particular, in work that endangers human health and life.

In turn, the automation of devices supporting the water zone through the use of e.g. marine drones will significantly affect the safety of ship traffic in port channels and allow better planning and implementation of transshipment tasks. The smart port concept identifies a wide field of use for aerial and water (marine) drones. For air drones, inter alia, the following tasks are assumed:

- port infrastructure inspection,
- inspections of quays, buildings, cranes, holds, pipeline routes, solar panels,
- monitoring terminals for security,

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34 Ports run Big Data projects to increase correlations of data collected and processed, as well as to improve port security and security processes. For example, the port of Valencia has launched an innovative Big Data project with the intention of improving the efficiency of terminal logistics and advanced navigation. Vide: *PORT CYBERSECURITY…*, p. 57.

35 The blockchain system, in relation to the needs of seaports, is designed to secure distribution and workflow of documentation.

36 Some European ports have launched cloud projects to exchange data on an ongoing basis in a centralised way, such as the Port Single Window system, which is the central port data management system. The assumption of this approach is the flow of information between the Port Authorities, the operators and the Customs Office.

37 With the IoT platform it is possible to monitor port infrastructure, reloading works and to collect data. The implementation of the sensor system and RFID technology is crucial here, e.g. the Port of Rotterdam launched its own IoT platform by installing sensors on buoys and quays to optimise ship docking time and location. Vide: *PORT CYBERSECURITY…*, p. 57.

38 The ports of Amsterdam and Rotterdam have made their air and sea areas available to drones to improve port operations. Vide: (1) *Drones in the Amsterdam port area*, https://www.portofamsterdam.com/en/port-amsterdam/drones-amsterdam-port-area, [access: 28.06.2020]; (2) Vide: *Water drone is Rotterdam's latest port innovation*, https://www.portofrotterdam.com/en/news-and-press-releases/water-drone-is-rotterdams-latest-port-innovation, [access: 28.06.2020].

- supporting port supervisory authorities,
- taking action in specific situations, e.g. in the case of a detection of flameless fire and subsequent notification to the relevant services. It is advisable that the drones used for this type of activity have smoke detectors, optical and ionising sensors,
- control of maintenance on board ships, terminals,
- deliveries to ships and oil rigs,
- medical transport (e.g. blood and human organs),
- passenger transport (e.g. in rescue operations),
- transport of heavy loads,
- transport of materials to ships (supporting the offshore industry).

On the other hand, the potential use of water (marine) drones[39] is:

- use of unmanned boats equipped with a camera that can send images of the quay and thus carry out surveillance and inspection from the water surface (the aim is to complement the work of manned patrol boats),
- controlling the water environment to identify and neutralise unauthorised marine drones[40],
- constant inspection and reporting of the underwater quay lines' technical condition,
- monitoring of concrete structures, e.g. oil terminals,
- control of the water condition in terms of contamination (sampling),
- detection of leakages of liquids and hazardous substances using, inter alia, a thermal imaging camera,
- removal of waste from water, clearing docks,
- checking the quality status of the sides, rudders and propellers in ships moored in port,
- the role of harbour pilots (supporting ships' entrance to and exit from ports),
- determination of volume, dimensions of bulk goods,
- underwater search (drowned bodies or materials, etc.).

It should be emphasised that cybersecurity must be maximised, before such complex and extensive systems for managing infrastructure and port facilities, assuming a high degree of system integration and the amount of data processed, will be implemented.

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39 Cf. *Pojazdy bezzałogowe. Autonomiczny dron morski*, http://atol.umg.edu.pl/ev/dron/dron.html, [access: 28.06.2020].

40 Organised crime groups use air drones and small submarines to smuggle drugs. It is believed that it is a matter of time before autonomous ships integrate with marine drones to increase the efficiency of logistics and drug transport. Cf. (1) *Skuteczniejsze wykrywanie małych statków powietrznych i dronów ułatwi ochronę europejskich granic morskich*, https://cordis.europa.eu/article/id/418277-better-detection-of-small-aircraft-and-drones-helps-protect-europe-s-maritime-borders/pl, [access: 28.06.2020]; (2) *Robot Boats and Drug Subs. ENG prof and students developing autonomous boats to find drug traffickers*, https://www.bu.edu/articles/2017/autonomous-boats-and-drug-subs/, [access: 28.06.2020])

The main challenges of the smart port concept are:

- raising awareness and trainings on cybersecurity in the port ecosystem,
- building cybersecurity strategies,
- introduction of adequate security measures to protect against cyber-attacks,
- increasing the time and budget for cybersecurity,
- qualified management of automated equipment,
- complexity of information technology (IT) and operational technology (OT) integration.

Despite such serious challenges, the long-term implementation of the Smart Port concept can ensure significant benefits for the port. It is worth mentioning that a number of tasks defined under the smart port concept for air drones will soon be carried out in the Port of Gdynia, thanks to the implementation of KSD. Moreover, in the future, water (marine) drones can interact with aerial drones under the control of KSD (vide: Fig. 4).

Fig. 4. One of the water (marine) drones used in the Port of Rotterdam, the Netherlands[3]

The idea of using water (marine) drones also indicates the direction of further potential development of the KSD and expansion of its functionalities, or a possible area of integration with another dedicated port system responsible solely for the supervision of water (marine) drones operating in the port water zone, as part of a long-term strategy for the implementation of the smart port concept. However, it should be borne in mind that the assumption of such an approach creates further dangers associated with cyberattacks. The fundamental question is: will the financial outlay on cybersecurity not be greater than the benefits of implementing the smart port concept?

41 Own study based on: *Water drone is Rotterdam's latest port innovation*, https://www.portofrotterdam.com/en/news-and-press-releases/water-drone-is-rotterdams-latest-port-innovation, [access: 28.06.2020].

CHALLENGES AND RECOMMENDATIONS FOR KSD OF THE PORT OF GDYNIA

In the course of analysis of the KSD of the Port of Gdynia potential, the following challenges were identified, which are important for the success of the project:

- the combination of civil and military infrastructure in the Port of Gdynia – the problem here concerns e.g. radio interference,
- providing a technical backshop for drones, including places for charging, storing, modernizing, servicing and operating – in addition to the implementation of KSD, future plans for day-to-day operation should be developed,
- UAV's resistance to extreme weather – will KSD operate in strong breeze or fresh gale conditions (limit of 6B, 7B or 8B)?[42]
- 24/7 continuous operation – does KSD provide organizational and technical 24/7 continuous operation capabilities? What is the estimated annual availability time of the system including failures, service, planned inspections and variability of weather conditions?
- functional requirements definition, e.g. monitored parameters, logged events, authentication and authorization/permission control, interfaces to other systems and APIs, etc. – there must be an accurate specification of the requirements for the system,
- non-functional requirements definition, e.g.: availability, resiliency, security, scope and degree of integration, scalability, data retention, etc. – it is suggested to draw up an accurate specification of the requirements for the system,
- cybersecurity and cyber-resilience – the system should absolutely be resistant to the attempts of cybernetic impact.

In view of the above, it is recommended to:

- recognise KSD as a strategic project in the area of security of the Port of Gdynia,
- carry out a deep and regularly repeated risk analysis,
- conduct the analysis of issues related to the protection of sensitive data and the privacy of persons within the scope of the system,
- ensure that the agreement clearly defines the responsibilities of the Supplier and the Recipient of KSD (ZMPG),
- precise the specification of functional and non-functional requirements and scope of integration of KSD (e.g. PANSA UTM, other existing Recipient's systems, etc.),

[42] Description of the wind force in Beaufort scale is using degrees. Strong breeze is 6B; high wind, moderate gale and near gale is 7B; gale and fresh gale is 8B.

- establish a team of experts on the side of the ZPMG,
- monitor the work progress carried out by the Supplier within the monitoring committees and the project steering committee on a regular basis,
- verify the compliance of the solutions provided by the Supplier with the contract at each stage of implementation,
- build the knowledge and competences in the operation of the integrated KSD already at the design stage,
- carry out penetration, integration and load tests before the acceptance of delivered KSD (preferably by a third party),
- perform User Acceptance Testing (UAT) before the acceptance of delivered KSD (via ZMPG),
- take the view that the integration of all systems into a single solution and the deployment of local IT infrastructure within the CEDD are essential for the success of the port security strategy.

SUMMARY

The purpose of this article was an attempt to present selected innovative security strategies for the infrastructure of the Port of Gdynia, taking into account the use of unmanned aerial vehicles (UAV's) as part of the implementation of the smart port concept. The article pays particular attention to the challenges related to the plans for the implementation by the Port of Gdynia Authority SA the Comprehensive Drone System (KSD) and the integration of UAV's with the maritime economy. It was recommended that integration with the U-space foundation, the PANSA UTM system, is crucial for the operation of this system. In particular, it is indicated that all components of the KSD system, i.e. DTM, LSM and Antydron, are integrated to achieve the full usability of the solution.

The aim of the article was to determine the extent to which Port of Gdynia could use aerial and water (marine) drones, as well as identify the challenges relevant to the success of this project. Global digitisation obliges Port of Gdynia to initiate new solutions in the area of cybersecurity and infrastructure. The biggest challenge is to gain the benefits from the implemented innovative concepts that justify the financial outlays. The challenges and recommendations set out in the article may be the beginning of further research into port infrastructure security.

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ASSURANCE OF EFFECTIVE FOLLOW-UP OF PROLONGED COSTLY TASK CONTRACTS USING BIOMEDICAL METHODS

Abstract: The aim of the present project is to: determine the level of influence of neurofeedback sessions on the phenomena of the stress model experienced during isolation according to molecular, biochemical, neurophysiological and psychomotor signatures. We believe that according to selected stressors, the result will be similar and that neurofeedback sessions will reduce the level of stress in various areas and stabilise the motivation to perform difficult tasks over a longer period of time. Against this background, the authors will identify and deconstruct the existing legal, psychological and biological conditions of human work under a high stressor – isolation, that can be found in three basic areas that the authors intend to study: offshore oil rigs, polar stations and space missions. Finally, the authors aim at designing an optimal standard form contract, supplemented with collected results of a designed set of biomedical tests performed at the pre-contractual stage, as well as measures to influence the human stress response at the contract implementation stage, which would reduce the uncertainty and thus the risk for any of the parties to such a contract, as well as any third parties that might be affected by human mistake in effectuating high-risk high performance contracts.

Keywords: high-risk high performance contracts, work under stress, isolation, astronauts, polar scientists, oil-rig workers, neurofeedback, biomedical methods & the law, safety culture, informed consent

1. PROPOSAL ABSTRACT

Aim 1. Defining the level of influence of neurofeedback sessions on stress model profiles experienced during isolation according to molecular, biochemical, neurophysiological, psychomotorical signatures.

Aim 2. To identify and deconstruct the existing legal, psychological and biological conditions of human labour performed under high levels of stressors: eg. isolation, sleep-deprivation, psychological pressure resulting from multitasking and team work, in an environment aggressive for the human body, displaying properties such as: extreme temperatures and pressure, very high or low humidity, polar night/day, magnetic storms etc. Such conditions can be identified in three basic fields the authors are intending to scrutinize: offshore oil-rigs, polar stations and space missions.

Aim 3. To design an optimal standard form contract supplemented by a set of biomedical tests done at the pre-contractual stage, as well as means of influence on human stress-reaction at the stage of contract performance, that would reduce uncertainty and thus risk inevitably placed on either party to such a contract[1]. In this context, greater attention should be paid to obtaining informed consent from those involved in such activities. The contemporary doctrine of informed consent does not provide further guidance in this regard, other than indicating that the provisions will define the final scope of this institution. However, a problem arises from the domestic perspective: "Is the question….?" Is the doctrine of "informed consent" in the context of isolation meant to be synonymous with "informed consent" in the context of Polish medical law? If so, then these opposing legal liability regimes may be incompatible in goals and purpose. The logical consequence of such a situation would be to redefine the regime of informed consent for purposes such as high-risk missions that fell categorically outside the context of medical law. We suggest a rights-based approach, referred to in the literature as "informed decision making", signifying the process through which astronauts make individual decisions to participate in specific long duration activities[2].

Subject: A case control approach will be followed comprising of healthy male and female participants: 50f + 50m for the experiment group and 50f + 50m for control group.

Methods: The following methods will be used: genes expression changes connected with stress reaction of human cells (e.g. *IL6, IL6R, Il1B, CYBA, CYBB, TNFA CCL2, CCL3, CCL5, CCR2, CCR3, CCR4*) expression changes of genes recognized as associated with human psychological abilities (e.g. *DRD2, DRD3,*

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2 R.R. Faden, T.L. Beauchamp, A history and theory of informed consent. New York: Oxford University Press; 1986.; J. Emanuel, D. Wendler, C. Grady, What makes clinical research ethical. JAMA. 2000; 311(9), pp. 2701–2711.

DRD4, DAT1, DBH, COMT, TPH2, ANKK1, MAOA, CHRNA4) or in case of difficulties of blood sampling miRNA profiling of saliva samples will be conducted; Vienna Test System: eye – hand, stress tolerance, attention, memory with sEMG (m. rectus abdominis, m. trapezius), which allows precisely to record the duration of latent voluntary contraction and relaxation, can be used for assessment of the intensity of central commands that control muscle contraction; questionnaires: KPS (stress feel), UMACL (mood) *Plopa, Markowski,* Neo-PI-R (personality), PERMA (well-being) ,PERMA – Kern; EEG brainwaves signals evaluation (alpha, beta, gamma, theta, and delta), which reflects the mental state of subjects.

Experiment: Defining the base level – measurement no. 1 of each stress signatures before the stressor (isolation) will be engaged. Creating two groups: experiment and control. All subjects will be exposed for isolation (up to 12 months). After a few months we will take measurement no. 2 to find out the differences between the base line and the line after the isolation. Neurofeedback session (the ability of EEG self regulation shaping, each subject independently regulates mental states responsible for the EEG record) will be implemented to the experiment group. After the isolation both groups will participate in the measurement. Based on results stemming from biomedical methods, legal issues will be addressed. The legal sciences project specialists will work to identify and deconstruct the existing legal – related to psychological and biological – conditions of human labour performed under high levels of stressors: eg. isolation, sleep-deprivation, psychological pressure resulting from multitasking and team work, in an environment aggressive for the human body, displaying properties such as: extreme temperatures and pressure, very high or low humidity, polar night/day, magnetic storms etc. Such conditions can be identified in three basic fields the authors are intending to scrutinize: off-shore oil rigs, polar stations and space missions. Based on comparative analysis of law and its practice, which inadequately addresses the identified problem, taking also the law and economics approach focused on efficiency, optimal standard form contracts shall be designed. They will be supplemented by printed results of a set of biomedical tests done at the pre-contractual stage, as well as means of influence on human stress reaction at the stage of contract performance, that would reduce uncertainty and thus risk inevitably placed on either party to such a contract. Consequently, all parties to the contract will be significantly relieved of those uncertainties and given the necessary insurance – premiums will need to be calculated after taking these factors into account, thus, as we expect, they will be considerably lower.

2. EXPERIMENT SCIENTIFIC OVERVIEW

2.1. SCIENTIFIC BACKGROUND

PROPER EXECUTION OF HIGH-RISK HIGH PERFORMANCE CONTRACTS

Proper performance of contracts (be it long-term – as in space missions, or short-term, but requiring unusual flexibility and perseverance, which could be reflected upon as the modern-day precarity, even if well-paid)[3] is of utmost importance within the three fields of application covered by the study. An anthropological perspective offered by Filipe Cãlvao does not seem exaggerated or unfit even in this context: "cases of enslavement are often presented as symptomatic aberrations that produce a pretense of normalcy in a time of uncertain futures"[4]. Such might occasionally be the sentiment of well-paid and highly-estimated astronauts reaching for the stars and and enabling the giant leap for mankind with „one step"[5], scientists discovering the mysteries and properties of Northern Lights on the North Pole, or oil-rig workers agreeing to – even if also superficially enjoying – constant demands for high flexibility[6].

As regards labour agreements within this scope, certainty and pay-offs on both sides are highly desirable[7], though not always present. Oil companies operate with very short standard forms – the worker's task is to tick the relevant box where the box has not yet been filled out by the employer, and sign 2 copies of the contract. Its full content is in fact mystery to the employee, who may not be skilled enough to read through hundreds of pages of contract codes, labour codes and collective agreements for the given sector of industry, often in a foreign language, let alone become acquainted with judicial interpretation thereof. On the other hand, the employer takes the risk of hiring a person unfit for the intended purpose of the contract. The case will be slightly improved with polar stations' staff and astronauts, as there are much less of them, and they usually had been highly qualified engineers, academics etc. that may be a little more informed and aware of risks inherent in the job they are tasked with, but the main problems resulting from highly stressful and unusual working conditions remain the same.

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3 cf. H. Pristed Nielsen, Offshore but on track? Hypermobile and hyperflexible working lives, Community, Work Family 2016, 19:5, pp. 538-553, Remuss 2011, van Baarsen 2011

4 F. Calvão, Unfree labour [in:] Annu. Rev. Anthropol. 2016/45, pp. 451–67.

5 W. White, Salvage Law for Outer Space [in:] Engineering, Construction and Operations in Space, Proceedings of the Third International Conference, Denver, Colorado 1992, p. 2416.

6 H. Pristed Nielsen et al, op. cit., pp. 546-548. I. Perry, P. Kfir, Title IV of the U.S. Commercial Space Launch Competitiveness Act of 2015: A Critical Step Forward in Facilitating the Development of a Viable Space Infrastructure, New Space, 1 Sept. 2017 r., vol. 5, no. 3, https://doi.org/10.1089/space.2017.0008

7 R. Cooter, T. Ulen, Ekonomiczna analiza prawa, CH Beck, Warszawa 2009, pp. 269-271.

LEGAL RISKS AND BIOMEDICAL METHODS OF LIMITING THEM

Risks arising from uncertainty as to the fitness for work in extreme conditions are present and real not only for the parties, but also for a number of stakeholders interested in proper performance of such exceptional labour contracts: O&G companies, research institutions, launching states or mission integrators – all being nowadays both government actors and private corporations[8] – but also any other states, NGOs, trade unions, or regular citizens who may be severely affected by a human mistake resulting in grave consequences in tort but also infringement within the human rights protection system[9]. This is the case with oil platforms/installations explosions and gigantic oil-spills[10] or spacecraft failures[11], which could be related to the human factor; perhaps less so with unfit polar stations' staff.

All the above stakeholders: the workers who invested time, money and lost opportunities (eg. family life) in their education and/or training; the employers, who invested in building the expertise and facilities necessary to carry out the prescribed highly demanding tasks, but – necessarily – also in the training and education of the crew members they fill those facilities with; and – though not at the center of our research but not to be neglected – any other potentially interested above mentioned third parties, including insurers, have different: more scientific and ecological, or more profit-oriented stakes[12]. A level playing field could be

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8 V. Kayser, Private Involvement in Commercial Space Activities: Legal Issues and Recent Trends, 37th Proc. L. Outer Space 1994, p. 315; A. Berman, A pluralist Approach to International Law, 32(2) Yale J. Int'l L. 2007, p. 316.

9 Including, but not limited to, environmental justice. See: Seibert-Fohr, The Fight against Impunity under the International Covenant on Civil and Political Rights, Max Planck Yearbook of United Nations Law 2002, no. 6, p. 306.

10 Cf. the case of Deepwater Horizon, in 2010, and Odebrecht NS-32, in 2017; M. Konopacka, Metody i poziom zintegrowania prawa państw członkowskich UE w sferze ochrony środowiska morskiego [in:] Unia Europejska : zjednoczeni w różnorodności: konferencja, Warszawa, 14-15 grudnia 2010 r., ed. Cezary Mik, Wydawnictwo Sejmowe, Warszawa 2012, p. 467-470; . E. M. França, E. Hollnagel, I.J.A. Luquetti dos Santos, N. Haddad, FRAM AHP approach to analyze offshore oil well drilling and construction focused on human factors [in:] Cognition, Technology Work (2020) 22:653–665 https://doi.org/10.1007/s10111-019-00594-z, Springer- Verlag London Ltd., part of Springer Nature 2019, p. 653; M. Abimbola, F. Khan, N. Khakzad, Dynamic safety risk analysis of offshore drilling. J Loss Prev Process Ind Elsevier Ltd. 30 (1) 2014 , https://doi.org/10.1016/j.jlp.2014.05.002, pp. 74-85.

11 M. Konopacka, „State liability for outer space activities" [in:] Per mare ad astra. Space technology, governance and law, Gdansk 2019 (eds. E. Wittbrodt et al.), Polska Akademia Nauk 2019, pp.162-163, 167- 168, errest A., The Liability Convention [in:] Workshop on Capacity Building in Space Law, United Nation/International Institute of Air Space Law, The Hague 18-19 November 2002, p. 2.

12 B. Lord, On the Economic Use of Outer Space: A Clash of Values [in:] Air Space Law 44, no. 2 (2019), p. 144; Kennedy D., Law and the Political Economy of the World [in:] Critical Legal Perspectives on Global Governance: Liber Amicorum David M Trubek 2013, edited by G. de Burca, C. Kilpatrick, J. Scott, pp. 88-89.

created with the use of state-of-the-art biomedical techniques, highly reliable and less fallible than the arcana of legal interpretation in case of a dispute, including Neurofeedback, and combining them with comparative legal analysis of
a) contractual fairness[13]
b) protection of workers[14],
c) liability for non-performance of contract[15] and
d) informed consent.

DESCRIPTIVE AND NORMATIVE APPROACH – DEVISING OPTIMAL LEGAL DOCTRINES

The above research shall be based on appropriate European and American rules originating in common contract principles – DCFR and ALI Restatement of Contracts supported by relevant case-law and coupled by labour law provisions, including collective agreements from selected jurisdictions most frequently referred to in our context, as assessed by the EFTA Court, the CJEU in Europe[16] or federal and supreme courts in the US. In addition, relevant domestic, European and international standards and rules on informed consent shall be examined. It is the normative, not descriptive analysis that is at the center of our legal research plan. We submit that the law's unexpected and often unintended consequences[17], resulting from non-performance or improper performance of the analysed types

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13 P. Schlechtriem, *Good Faith in German Law and in International Uniform Laws* (Centro di studi e richerche di diritto comparato e straniero, Saggi, Conferenze e Seminari, Roma 1997; Kötz H, Towards a European Civil Code: The Duty of Good Faith in The Law of Obligations. Essays in Celebration of John Fleming, ed. Peter Cane, Jane Stapleton, Clarendon Press, Oxford 1998; Konopacka M., Dobra wiara w prawie umów [in:] Prawo prywatne w dobie przemian, Wyd. UG, Gdańsk 2005.

14 M. Konopacka, Deficyt solidarności, czyli status polskich pracowników delegowanych w RFN. Glosa do wyroku ETS z dnia 3 kwietnia 2008 r., C-346/06 Rüffert, Gdańskie Studia Prawnicze. Przegląd Orzecznictwa. – 2014, nr 3, p. 89-102.

15 J. Gordley, The Foreseeability Limitation on Liability in Contract [in:] Towards a European Civil Code, ed. A. Hartkamp, M. Hesselink, E. Hondius, C. Joustra, E. du Perron, M.Veldman, Ars Aequi Libri, Kluwer Law International, Nijmegen 2004, pp. 215-228.

16 M. Konopacka, „Zasady Europejskiego Prawa Umów" [in:] „Ochrona praw jednostki", seria „Acquis communautaire», vol. 6, ed. Z. Brodecki, LexisNexis 2004.; O. Lando, Non-Performance (Breach) of Contracts [in:] Towards a European Civil Code, ed. A. Hartkamp, M. Hesselink, E. Hondius, C. Joustra, E. du Perron, M. Veldman, Ars Aequi Libri, Kluwer Law International, Nijmegen 2004, p. 506-510, M. Konopacka, Deficyt solidarności, czyli status polskich pracowników delegowanych w RFN. Glosa do wyroku ETS z dnia 3 kwietnia 2008 r., C-346/06 Rüffert, Gdańskie Studia Prawnicze. Przegląd Orzecznictwa. – 2014, nr 3, pp. 89-102.

17 C-W Canaris, H. Ch. Grigoleit, Interpretation of Contracts [in:] Towards a European Civil Code, ed. A. Hartkamp, M. Hesselink, E. Hondius, C. Joustra, E. du Perron, M.Veldman, Ars Aequi Libri, Kluwer Law International, Nijmegen 2004, p. 445 et. seq.; J. Stelmach, Wokół pojęcia interpretacji prawniczej, R. Sarkowicz, Metody interpretacji tekstu prawnego [in:] Teoria prawa, Monografie Wydziału Prawa i Administracji Uniwersytetu Jagiellońskiego, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków 1998, pp. 61-91.

of high-risk high performance contracts[18], could be significantly mitigated, if not eliminated, with the use of extra-legal solutions. Ostrich-like tactics cannot prevent lawyers from admitting that the law and its practice are far too often vague and unpredictable, especially if being captured by non-democratic regimes or interest groups that forward profit-oriented goals.

In addition, globalisation makes the law a frequent object of misappropriation by conflicting interest-groups, next to traditional vulnerability to choice-of-law and jurisdiction more favorable to the stronger party[19], forum shopping[20], lengthy court proceedings, or ADR: less time-consuming, better preserving trade secrets and reputation, but costly arbitration, or mediation – swifter and optimal, but requiring mutual concessions[21]. Scarce interdisciplinary studies already undertaken in a neighboring field focus on the interplay of management, technology and the failure of the human factor, applying FRAM AHP approach where the "lack of control of these processes, associated with the workplace, can cause potential losses, injuries to workers, and fatalities"[22]or assessing the anthropological impact of „hypermobile and hyperflexible working lives on communities, work and family by interviewing local oil-rig workers and employers[23]. Given the above and taking into account all legal problems and lacunae identified, there is urgent need for engagement into the proposed interdisciplinary experimental study and its immediate application.

THE DEMAND FOR GREATER CLARITY OF HIGH-RISK HIGH PERFORMANCE CONTRACTS

With respect to high-risk high performance contracts, it is utterly important to formulate the tasks in a clear and comprehensible manner. Interpretation problems may arise at any stage of the contract's existence: at the time of its

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18 T. Wiśniewski [in:] Komentarz do kodeksu cywilnego. Ksiega trzecia. Zobowiazania, wyd. 6, ed. G. Bieniek, Wydawnictwo Prawnicze LexisNexis, Warszawa 2005, pp. 583-588., O. Lando, 'Salient Features of the Principles of European Contract Law: a Comparison with the UCC' (2001) 13 Pace Int'l L Rev; J. Gordley, The Foreseeability Limitation on Liability in Contract [in:] Towards a European Civil Code, ed. A. Hartkamp, M. Hesselink, E. Hondius, C. Joustra, E. du Perron, M.Veldman, Ars Aequi Libri, Kluwer Law International, Nijmegen 2004, p. 215-228.

19 M. Konopacka, Dobra wiara w prawie umów [in:] Prawo prywatne w dobie przemian, Wyd. UG, Gdańsk 2005.

20 M. Konopacka, Zasada ścisłego związku [in:] Europa Sędziów, ed. Z. Brodecki, LexisNexis, Warszawa 2007.

21 M. Konopacka, Mediation in closed circles: two examples, Kwartalnik PCM „Mediator" nr 1/2015, pp. 15-35.

22 J. E. M. França, E. Hollnagel, I.J.A. Luquetti dos Santos, N. Haddad, FRAM AHP approach to analyze offshore oil well drilling and construction focused on human factors [in:] Cognition, Technology Work (2020) 22:653–665 https://doi.org/10.1007/s10111-019-00594-z, Springer-Verlag London Ltd., part of Springer Nature 2019, p. 653.

23 H. Pristed Nielsen, op.cit., pp. 538-553.

conclusion, performance, non-performance or improper performance. The expressions used to formulate the contract can sometimes be ambiguous, too vague, contradictory or unclear in the context of the entire content of the contract. Sometimes, in the absence of additional contractual provisions, it will be necessary to interpret this gap. Often, a given interpretation may lead to the conclusion that the contract has not been performed or is invalid. The question of interpretation is primary and logically separate from the question of the validity of the contract and the legal remedies available to the party.

It is necessary to precisely define the meaning of contractual clauses before it can be clearly stated that there has been a breach of certain provisions thereof, which would be the basis for the claim for damages or specific performance. It also happens that the very fact of concluding the contract is questioned[24]. Contractual compliance *(pacta sunt servanda)* is the highest principle and is crucial for the completion of high-risk, high performance missions, expeditions or any similar multi-tasked and stressful, especially long-term solitary confinement posts. Whereas in some extreme circumstances it would be unfair for one of the parties to insist on performance of the obligation strictly in accordance with the terms of the contract, which would be an excessive burden on the counter-party, the *rebus sic stantibus* clause cannot be a field for abuse, therefore the change in the economic or social situation and the negative effect for one of them, not previously foreseen by the parties, must be assessed objectively[25].

This effect may take the form of a threat of gross loss or excessive difficulties, and the change may not be only temporary. In this case, renegotiation of the contract might be possible in order to adjust its provisions to the changed relations or even to terminate the contract. However, it is only permissible if the change of relationship took place after the conclusion of the contract, which could not be reasonably foreseen and the party whose interest was violated cannot be expected to bear the risk of this change. Depending on the cause of the non-performance, it may be excused or unjustified. European contract law regimes provide for the limitation of liability in the event that the performance of a party has become impossible for reasons for which it is not responsible and which could not be foreseen at the time of the conclusion of the contract, or it was impossible to avoid the obstacle, overcome it, or avoid/overcome its effects.

With regard to non-pecuniary liabilities, the creditor may require the "performance of a specific" obligation; this is a legal remedy also applicable in the event of defective performance. While it is usually the last resort for courts in most types of contracts, personal performance by a person trained and skilled to do it, in accordance with the original aim and wording of the contract, is crucial for the success of a given endeavor. Humans have the most adaptable abilities on

24 C-W Canaris, H.Ch. Grigoleit, op. cit., pp. 445 et. seq.

25 L. Olsen, The choice of the aggrieved party – An analysis of the remedies in the Principles of the European Contract Law, ERPL 1/1999, Kluwer Law International.

Earth. Human cognitive and perceptual psycho-motor performances deteriorate under different kind of stressors. Understanding the neurophysiological and neuropsychological parameters influencing difficult conditions is of high relevance to wide group of scientists including neuroscientists and psychologists. Environmental characteristics specific to prolonged isolation may influence neurophysiological and psychological efficiency.

IMPROVING THE ODDS OF PROPER CONTRACT PERFORMANCE THROUGH BIOMEDICINE

There are tools and procedures that have been developed to assess and deal with deficits and problems defined above. It is yet unknown how the brain will adapt e.g. to long-term travel to low Earth orbit and beyond[26]. Perceptions of working in difficult conditions are affected by two important factors: motivation and stress. This could obstruct effective goal execution, as well as create stress among the people involved[27]. The important necessity appears to identify markers of differential vulnerability to changes during the prolonged isolation and the need to ensure maintenance of circadian entrainment, sleep quality and quantity during exploration missions. Successful adaptation to such conditions will require crew prepared to surface habitats that instantiate aspects of Earth's geophysical signals[28]. There is a close correlation between human stress and motivation and EEG Power Spectrum of Beta and Alpha band[29].

Numerous publications provide evidence that stressful early life experiences (e.g. social isolation) can affect brain development and influence behavior. There is also evidence to suggest there are different responses between sexes to stress. Although the underlying mechanisms are still poorly examined, it seems to be clear that in humans similar environmentally-induced changes could be considered as main factors in the basis of psychiatric disorders such as schizophrenia, depression or anxiety disorder. Moreover, isolates need more time to enter a new environment, they show neophobia and increased defecation in the open field. Most studies shows no effect of social isolation on the basic corticosterone level, others demonstrate either increased or reduced basal corticosterone levels after social isolation. According to both 'physical' and 'physiological' stress treatments,

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26 G. De la Torre, Cognitive Neuroscience in Space, Life, 4/2014, pp. 281-294.

27 M. Gällstedt, Working conditions in projects: perceptions of stress and motivation among project team members and project managers, International Journal of Project Management, Volume 21, Issue 6, August 2003, pp. 449-455.

28 M. Basner, D. Dinges, D. Mollicone, A. Ecker, Ch. Jones, E. Hyder, A. Di Antonio, I. Savelev, K. Kan, N. Goel, B. Morukov, J. Sutton, Neuroscience Mars 520-d mission simulation reveals protracted crew hypokinesis and alterations of sleep duration and timing, Proc Natl Acad Sci. USA. 2013, Feb 12; 110(7), pp. 2635–2640.

29 Hayatee N., Hamid A., Sulaiman N., Siti Armiza Mohd Aris, Zunairah Hj Murat, Mohd Nasir Taib, Evaluation of human stress using EEG Power Spectrum, IEEE, 2010 6th International Colloquium on Signal Processing its Applications.

the release of adrenocorticotropic hormone and corticosterone were found to be increased (adrenocorticotropic hormone injection; open field exposure; foot-shocks) or unchanged following social isolation (forced swim)[30].

However, there is growing evidence to suggest the miRNA profiling can be an effective biomarker to be used in prognosis of disease and, more interestingly, there is a growing body of knowledge to suggest that specific miRNAs are altered in response to altering stress induced environments. Furthermore, it has been well documented that dysregulation of amygdala neural circuitry—a brain region associated with emotions—is central to the development and maintenance of symptoms experienced by subjects with post-traumatic stress disorder[31] study of the individually determined upper alpha frequency band in EEG (electroencephalogram) was investigated as a neurofeedback parameter.

Fourteen subjects were trained on five sessions within 1 week by means of feedback dependent on the current upper alpha amplitude. The author responsible for the biomedical part of the present research tested cognitive ability on the first and fifth session using a mental rotation test. Results showed significant training success. Individually determined upper alpha was increased independently of other frequency bands. The increase in the level of cognitive performance was significantly larger for the neurofeedback group than for the control group, who did not receive feedback. The increased level of cognitive control went along with an increased upper alpha amplitude that was found in the neurofeedback group only. Neurofeedback may help remedy chronic post-traumatic stress disorder. Results demonstrated in this population can be implemented to all stress disorder subjects[32]. The cellular stress response is evolutionarily conserved in all living organisms, and a significant role is attributed to many molecules that confer stress protection.

The molecular responses elicited by the cells dictate whether the organism adapts, survives, or, if injured beyond repair. Most of the time these responses are beneficial to the organisms. Our detailed understanding of stress responses has paved the way for the development of stress tolerant crops in several instances. Considering all these, studies on stress responses turned out to have broad bio-

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30 I. Weiss, Ch. Christopher Pryce, A. Jongen-Rêlo, N. Nanz-Bahr, J. Feldon, Effect of social isolation on stress-related behavioural and neuroendocrine state in the rat. Behavioural Brain Research, Volume 152, Issue 2, 9 July, 2004, pp. 279-295.

31 Nicholson A., Rabellino D., Densmore M., Frewen P., Paret Ch., Kluetsch R., Schmahl Ch., Théberge J., Neufeld R., McKinnon M., Reiss J., Jetly R., Lanius R., The neurobiology of emotion regulation in posttraumatic stress disorder: Amygdala downregulation via real-time fMRI neurofeedback, Human brain mapping Volume 38, Issue1, January 2017, pp. 541-560. B. Zoefel, R. Huster, Ch. Herrmann, Neurofeedback training of the upper alpha frequency band in EEG improves cognitive performance, NeuroImage, Volume 54, Issue 2, 15 January 2011, pp. 1427-1431.

32 M. Askovic, A. Watters, J. Aroche, A. Harris, Neurofeedback as an adjunct therapy for treatment of chronic posttraumatic stress disorder related to refugee trauma and torture experiences: two case studies, Australian Psychiatry, 2017, Volume: 25 issue: 4, pp. 358-363.

logical applications in humans[33]. Acute stress initiated by simulated severe intra--operative bleeding significantly influences (decreases) psychomotor performance during the acute stressful episode[34]. There are detected stress reactions from muscle activity because of the possible benefits in prevention of musculoskeletal disorders. Several investigations were reported on the effect of mental stress on muscles. Experiments used the electromyography (EMG) from e.g. the upper trapezius muscle, from which various features were extracted to quantify muscle activity.

The Stroop color word test and different mental arithmetic tasks are the most popular ways to induce mental stress. The changes in EMG included an increase of amplitude and a decrease in the amount of gaps (short periods of relaxation) that were recorded. Both are indications of elevation of muscle activity, caused by the stress tasks. EMG could be an easily wearable wireless system that can measure real time stress levels [35].

2.2 OBJECTIVES

1. Defining the level of influence of the neurofeedback sessions in lowering the stress reaction level according to isolation on molecular, biochemical, neurophysiological, psychomotoric and psychological level.
2. Creating model profiles of stress response on molecular, biochemical, neurophysiological,
3. psychomotoric and psychological level according selected stressors.
4. Defining the effective number of neurofeedback sessions significant in lowering the stress level according to isolation.
5. Defining the most significantly informative areas (molecular, biochemical, neurophysiological, psychomotoric and psychological) according to negative influence of the isolation.
6. Identify differences in stress reactions and any potentially differences in recovery from stress between the sexes.
7. Identify a potential miRNA and/or DNA profiling signature to be used as a biomarker for a stress reaction and a recovery phase which can be used as a biomarker to monitor, evaluate and prescribe an intervention in an extreme environment.

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[33] A. Grover A., Molecular biology of stress responses, Cell Stress Chaperones. 2002 Jan; 7(1), pp. 1-5.

[34] K. Bajunaid, M.A. Mullah, A. Winkler-Schwartz, F. E. Alotaibi, J. Fares, M. Baggiani, H. Azarnoush, S. Christie, G. Al-Zhrani, I. Marwa, A.J. Sabbagh, P. Werthner, R.F. Del Maestro, Impact of acute stress on psychomotor bimanual performance during a simulated tumor resection task, J Neurosurg. 2017 Jan;126(1, pp. 71-80.

[35] J. Wijsman, B. Grundlehner, J. Penders, H.J. Hermens, Trapezius Muscle EMG as Predictor of Mental Stress, Conference: Proceedings of Wireless Health 2010, WH 2010, San Diego, CA, USA, October 5-7, 2010.

8. Defining the level of impact of the results achieved in biomedical experiment in assurance of effective follow-up of prolonged costly task contracts.

2.3 HYPOTHESIS AND EXPECTED RESULTS

1. The neurofeedback sessions will significantly lower the level of stress experienced from isolation as also reflected in the molecular, biochemical, neurophysiological, psychomotorical and psychological profiling areas.
2. Lowering the stress level will increase the motivation of executing the tasks in extended time period.
3. The miRNA and/or DNA signature profile can we used to monitor non invasively an individuals response to and recovery from a stress induced environment.
4. Results achieved in biomedical experiment in assurance of effective performance will allow to handle "undefined" resignations from follow-up of prolonged costly task contracts.

Based on experiments already executed by the biomedical research expert, we can state that neurofeedback sessions effectively lower the stress level in molecular, biochemical, neurophysiological, psychomotoric and psychological areas (around 39%). The most significant results appeared according to prolonged physical effort. We believe that according to stressor (human isolation) the result will be similar and neurofeedback sessions will decrease stress level on various areas and will stabilize the motivation to execute difficult tasks in prolonged time period.

3. BENEFITS FOR HUMANS

Assistance on the ground in the form of psychological support is of vital importance for the tranquility of the crew members as well as for the pursuit of their personal objectives[36]. The main benefit of the result of this proposed experiment is proposing an effective way of dealing with stress – lowering its level (using neurofeedback) connected with isolation as the main stressor and according to molecular, biochemical, neurophysiological, psychomotoric and psychological areas using individually prepared neurofeedback sessions performed during the isolation time period. In addition, the identification of a miRNA and/or DNA biomarker panel may assist in monitoring and evaluating an individuals response to and recovery to stress environment has patent potential. The information gained from these analyses may also assist us in understanding the diffe-

[36] D. A. Urbinan, R. Charles, Symposium keynote: Enduring the isolation of interplanetary travel. A personal account of the Mars500 mission, Acta Astronautica 93 (2014) pp. 374-383.

rences between male and female responses to and recovery from stresses. Based on the achieved results we will develop the score card to evaluate the stress level on various signatures and to prescribe the intervention procedure.

4. MANAGEMENT APPROACH

The project brings together a multidisciplinary team of researchers from Polish, South African, Ukrainian and Norwegian scientific institutions who have a proved track record in international, European, comparative and medical law, psychology, neurophysiology, psychomotorics and genomics. The individual team members are regarded as leaders in their respective fields as noted by the number of highly cited publications in their field of expertise. This multidisciplinary team will build on their existing knowledge and experience to execute the proposal, proliferate its outcomes and generate novel strategies to better characterize the impact of stress on human physiology which will enable the experiment-based approach to designing optimal legal doctrines and contract forms.

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SMART PORT- SMART WORK. OUTPLACEMENT, RETRAINING RE-SKILLING AND JUST TRANSITION

Abstract: The development of smart ports requires skilled and well educated workforce. Due to job polarisation, advancements in technology and automation will affect workers' groups differently, depending on the type of skills required and, more importantly, on to what extent specific tasks can be automated. Though improper handling of employees' concerns may result in downsizing a company's future profitability, in terms of post--termination costs to the company, dealing with the psychological issues of the discharged employees is perhaps even more important. A proactive approach and a balanced mix of short-term and long-term skills transfer and outplacement support can help ensure an organisation's workforce success, even in the toughest of economic times.

Keywords: employment, automation, smart port, professional development, employment contract, outplacement

INTRODUCTION

The concept of „smart port" has been developed on the canvas of "smart growth" approach to urban planning originating in the 1990s. From the historical perspective, it is perceived as the next generation of ports, the first being „isolated ports" before 1960s, followed by „expanded ports" in 1960s, „container ports" developing in 1980s, and „integrated ports" in 1990s, which already have made ample use of information and communication technologies[1].

Technological developments that lead to the 4th industrial revolution have had significant impact on various aspects of work and employment. First of all, it affects division of labour and the employment paradigm. Artificial Intelligence

[1] A. Molavi, G.J. Lim, B. Race, *A framework for building a smart port and smart port index*, International Journal of Sustainable Transportation, 2020, 14:9, p. 693.

(AI)[2] plays crucial role in developing solutions that shape modern employment market. Economic fields where AI is used, strongly connected to employment and labour market, include robotisation, dematerialisation and gig economy[3]. New models of work organisation also pose challenges as far as workers' qualifications are concerned, and in some cases it is necessary to reorganise and reduce the workforce.

The aim of the present paper is to summarise discussion around the influence of technological trends in ports on jobs and employment and reflect on the tools that are in disposal of the employer such as retraining, reskilling and outplacement. We will also consider the role of social partners in the process.

THE CONCEPT OF SMART PORT AND EMPLOYMENT

Smart ports' activity covers many inter-related elements, such as optimised operations enhancing port resilience, intelligent infrastructure and automation, as well as safe and secure activities[4]. All of these require skilled and well-educated workforce. One of important aspects of smart port operations is safety and security, managed by security management systems, which serve to identify potential threats and effectively establish, implement, monitor, review and maintain actions to ensure security[5]. This entails handling integrated monitoring and optimisation systems, which also support safety management systems. From workers' perspective, this structure increases the level of occupational safety. On the other hand, automated procedures require sufficient number of sensors and cameras following machine operations but also activities of workers themselves. If they are additionally equipped by wearables that measure their position and movement, enormous amount of information gathered may raise concerns about use of data and workers' privacy.

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[2] High-Level Expert Group on Artificial Intelligence set up by the European Commission proposes the following definition of the AI: Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions. (High-Level Expert Group on Artificial Intelligence, *A definition of AI:Main capabilities and scientific disciplines*, p. 8 https://ec.europa.eu/digital-single-market/en/news/definition-artificial-intelligence-main-capabilities-and-scientific-disciplines [access: 30.10.2020]

[3] IBA Global Employment Institute, *Artificial Intelligence and Robotics and Their Impact on the Workplace*, p.10 https://www.ibanet.org/Document/Default.aspx?DocumentUid=c06aa1a3-d355-4866-beda-9a3a8779ba6e [access: 30.10.2020]

[4] A. Molavi, G.J. Lim, B. Race, *A framework for building Smart Port* … p. 693.

[5] Ibidem.

Just as in other workplaces, rapidly increasing automation can improve safety and security. This is fully in line with the International Labour Organization's 2030 Agenda for Sustainable Development. Healthy and safe workplace for all is one of the elements of decent work[6]. New technologies can also be applied to balance working time and reduce OSH hazards connected to long working hours[7].

Conditions of work are also affected. Developments in automation and digitalisation may increase work safety and alleviate physical strain. Workers safety may be increased also through use of simulated environments in VR training programs[8]. While wearable devices may monitor workers' health, technology--enabled surveillance can lead to enhanced speed and efficiency pressure on workers, as Taylorist information control and discipline involve subjecting work tasks to detailed digital measurements and statistical analyses of individual worker performance[9]. This entails less autonomy of workers and in case advanced robots are used – less flexibility to manage staffing and planning issues[10].

NEW TECHNOLOGIES – NEW SKILLS

New technologies strongly impact skills use and skills development. Advanced robotics may bring shift from manual towards intellectual skills and use of wearables- need for supervisory skills[11]. In many sectors a phenomenon called job polarisation can be observed. Autor and Dorn note that "low-skill labour flows accordingly from goods to services, while high-skill labour remains in goods production, leading to employment polarisation"[12]. It is also noticed that

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6 ILO, *Time to act for SDG8. Integrating Decent work, Sustained Growth and Environmental Integrity*, ILO Geneva 2019, p. 21.

7 Other OSH risks connected to the use of AI and in particular increased monitoring and tracking, can rather be mitigated through traditional forms of collective bargaining. For OSH risks see : J. Popma, *The Janus face of the 'New Ways of Work', Rise, risks and regulation of nomadic work, Brussels*, ETUI, 2013 and Ph. V. Moore, Artificial Intelligence: Occupational Safety and Health and the Future of work, p. 3. https://www.stjornarradid.is/lisalib/getfile.aspx?itemid=4061219d-3a73-11e9-9432-005056bc530c [access: 30.10.2020]; EU-OSHA, *OSH and the future of work: benefits and risks of artificial intelligence tools in workplaces* 2019 https://osha.europa.eu/en/publications/osh-and-future-work-benefits-and-risks-artificial-intelligence-tools-workplaces/view [access: 30.10.2020].

8 Eurofound, *Game-changing technologies: Transforming production and employment in Europe*, Publications Office of the European Union, Luxembourg 2020, p. 20.

9 A.J. Wood, V. Lehdonvirta, M. Graham, *Workers of the Internet unite? Online freelancer organisation among remote gig economy workers in six Asian and African countries*, New technology Work and Employment 2018, 33(2), pp. 61-62.

10 Eurofound, *Game-changing technologies*, p. 35.

11 Eurofound, *Game-changing technologies*, p. 33.

12 D.H. Autor, D. Dorn , *The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market*, American Economic Review 2013, 103(5): p. 1559.

employment in routine-intensive middle-skill occupations is declining, which contributes to employment polarisation[13]. Developments in technology and automation will affect workers' groups differently, depending on the type of skills required, and on the extent specific tasks can be automated.

Initial discussions underlined impact of automation and digitalisation on routine jobs involving explicit rule-based activities[14]. Frey and Osborne confirm that cognitive and manual routine tasks are prone to computer substitution, as "computers are relatively productive to human labour when a problem can be specified in the sense that the criteria for success are quantifiable and can readily be evaluated"[15]. However, there are also many non-routine tasks that can be automated[16]. According to Frey and Osborne, technological progress and in particular use of big data allow for computerising also non-routine tasks, both manual and cognitive[17]. Automation of non-routine tasks depends on existence of any engineering bottlenecks to computerisation. These include:

- Perception and manipulation tasks, as robots are often still limited in matching the depth and breadth of human perception[18].
- Creative intelligence tasks. As creativity involves novelty and value. While there are examples of computers making unfamiliar combinations of familiar ideas (novelty), added value is still disputable, especially that values match change according to culture and time[19].
- Social intelligence tasks, as human social intelligence is important in many tasks, especially in services. Even though machines can now reproduce some aspects of human social interaction, and even pass Turing test, their ability to respond promptly and adequately is still not sufficient[20].

The pace of automation is also determined by other factors, such as price of the machines and automated systems (which is decreasing), as well as social acceptance for such changes. The impact of automation varies also from one country to another. For Poland the percentage of jobs at high risk of automation is estimated at 19,8% (30,5% for industry)[21].

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13 M. Goos, A. Manning, A. Salomons, *Job Polarization in Europe* American Economic Review 2009, 99 (2), p. 2514.

14 C.B. Frey, M.A. Osborne, *The Future of Employment: How susceptible are jobs to computerisation?*, Oxford Martin Programme on Technology and Employment 2013, p. 2. https://www.oxfordmartin.ox.ac.uk/downloads/academic/future-of-employment.pdf [access: 30.10.2020].

15 *Ibidem,* p. 14.

16 E. Brynjolfsson, A. McAfeesty, *Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy* 2011.

17 C.B. Frey, M.A. Osborne, *The Future of Employment*, p. 15-21.

18 *Ibidem,* p. 24.

19 *Ibidem,* pp. 25-26.

20 Ibidem, pp. 26-27.

21 R. Chinoracky, S. Tuska, L. Mamadlenakova, *Does Industry 4.0 have the same impact on employment in the sectors*, Management, 2019, vol. 14, issue 1, 5-17, p. 11.

NEW TECHNOLOGIES – NEW JOBS?

Similarly to other areas of economy, automation of processes in ports brings opportunities and challenges for workers. Automation and digitalisation are pivotal steps in transition into a smart port. It is estimated that currently 1% of ports are fully automated and only 2% semi-automated[22]. Just like in other branches of industry, containerisation and automation makes port operation and cargo handling decreasingly labour-intensive. Reduction of labour costs may reach even 60%[23] Using algorithms to measure and project work together with humane-machine interaction will increase productivity levels, but, at the same time, lower number of workers will be required to perform the same tasks and dockers will be able to work at more than one fully automated terminals[24].

Current job positions in ports include e.g. crane operators, industrial truck operators, construction specialists and workers, maintenance workers, dockers, equipment dispatchers and shift managers[25]. Their skills are described as: terminal operation, including waterway ship scheduling service; foreland transport service, including railway and road transport service connected to the port; hinterland transport service, including railway and road transport service connected to the port; and warehouses related to the port[26]. Authors of the "Transport 2040" report rightly suggest that, in case of port workers, automation will not make work easier, but rather more demanding and complex. New skills will be required to handle more complicated devices and co-operate with digital and physical robots. For example, obtaining general prior knowledge on mechanics and electronics will become indispensable, in order to be able to remotely control operation of the equipment and be able to asses bugs in information systems[27].

Decent work is one of the factors leading to more sustainable economy. Therefore, it is necessary for the port employers to prepare for inevitable transitions. News skills, such as data fluency, digital operation and basic software engineering, will become indispensable[28]. All the above, combined with previous experience of workers, is an argument for retraining workers instead of hiring

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22 International Transport Federation, *Automation and digitalisation: New Technology in Ports,* https://www.itfcongress2018.org/en/your-congress-your-voice/automation-and-digitalisation-new-technology-in-ports/ [access: 30.10.2020].

23 *Ibidem.*

24 World Maritime University, *Transport 2040: Automation, Technology, Employment – The Future of Work*, 2019, Reports 58, p.88. https://commons.wmu.se/lib_reports/58 [access: 30.10.2020].

25 *Ibidem*, p. 85.

26 *Ibidem,* p. 87.

27 *Ibidem,* pp. 87-88

28 *Ibidem*, p. 93

new staff to fill new high skill jobs. Also trade unions see the need to create tailor-made training programmes that allow workers to adapt to new job profiles and the changing work environment [29].

It is projected that the number of jobs in ports will decrease by 8,2 % with the advent of automation[30]. Social acceptance of automation and its impacts on jobs is not very high[31], as this would mean decreasing number of workers carrying out simple manual tasks. Some processes are more difficult to automate than others. For example, lifting and loading containers into a ship requires experience that workers gain during their work, as the container may move in an unpredictable way[32].

Among different job profiles, dock supervisors and docking pilots are among those with lowest potential of automation. Logisticians are also not very likely to be replaced by automated processes (1,2%)[33]. Other occupations that are most likely to be still needed are occupational health and safety specialists (17%) and OSH technicians (25%)[34]. The current level of automation, especially in case of docking pilots, is relatively low (about 15%) and the level of automation in the future is not expected to be above 30%[35]. However crane operators are among medium skill occupations with highest potential for automation (72 – 90%)[36]. Dockers, whose work is estimated to be automated in nearly 27% have high (82,5%) potential of automation by 2040[37]. They will not be required to be present on site, instead, they can work from dockside offices or even operate the cranes from another town or country[38]. At the same time, more workers employed as automation engineers or to maintain sensors and other equipment[39]. Retraining and reskilling workers does come as an opportunity, especially that this way of addressing the skill gap is more accepted by employers, at least in European countries[40]. McKinseyGlobal Institute recognises the important role of companies in the transition process, especially in training and re-training of

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29 World Maritime News, *Port automation friend or foe?* https://www.offshore-energy.biz/port-automation-friend-or-foe/ [access: 30.10.2020].

30 I. Vonck, *Ports of the future , a vision*. Deloitte Port Services. Baltic Ports Conference 2017 http://www.porteconomics.eu/mdocs-posts/2017-baltic-ports-conference-vonck/ [access: 30.10.2020].

31 World Maritime University, *Transport 2040* …p. 87.

32 International Transport Federation, *Automation and digitalisation op.cit.*

33 C.B. Frey, M.A. Osborne, *The Future of Employment*, p. 58

34 *Ibidem*, p. 61

35 World Maritime University, *Transport 2040,* p. 51

36 C.B. Frey, M.A. Osborne, *The Future of Employment*, p. 68

37 World Maritime University, *Transport 2040,* p. 48.

38 International Transport Federation, *Automation and digitalisation op.cit.*

39 *Ibidem*

40 P. Illanes, S. Lund, M. Mourshed, S. Rutherford, M. Tyreman, *Retraining and reskilling workers in the age of automation*, https://www.mckinsey.com/featured-insights/future-of-work/re-training-and-reskilling-workers-in-the-age-of-automation [access: 30.10.2020].

workers and building corporate training programs that merge on-the-job training with formal education through apprenticeships[41].

Technological change at work also influences industrial relations. While new technologies may facilitate communication and information exchange, new forms of work organisation, especially delocalisation and decreasing number of direct employees also strongly affect industrial relations. Not only the level of trade union participation may be affected, but also established threshold for information and consultation procedures may not be reached[42].

At the same time, conclusion of agreements allowing employers and workers to develop mutual relations in the form of binding norms of conduct[43], are gaining more importance in the light of the dynamic changes linked to automation processes. As far as the content of agreements is concerned, beyond traditional scope, there is an evidence of employers negotiating over the use of artificial intelligence, big data and electronic performance monitoring ("people analytics") at the workplace, as well as their implications for occupational health and safety, privacy, evaluation of work performance and hiring and firing decisions, but also the use of technology not only in monitoring workers but also in directing their work[44]. Collective agreements may contain "automation clauses" which allow for protection of jobs throughout the process of automation, as well as guarantee good working conditions in case of automation[45].

PERSONAL DEVELOPMENT OF EMPLOYEES

The rapid development of technology has resulted in changes in the port classification, therefore ports of the fifth and sixth generation are more often distinguished. Ports 5 GP provide handling services at the highest level in the world. Such ports include ports like Shanghai, Singapore, Hamburg and Rotter-

41 Mc Kinsey Global Institute. *Jobs lost, jobs gained: workforce transitions in a time of automation*, 2017, s. 107, 111.https://www.mckinsey.com/~/media/McKinsey/Industries/Public%20and%20Social%20Sector/Our%20Insights/What%20the%20future%20of%20work%20will%20mean%20for%20jobs%20skills%20and%20wages/MGI-Jobs-Lost-Jobs-Gained-Executive-summary-December-6-2017.pdf [access: 30.10.2020].

42 Eurofound, *Game-changing technologies*, p. 37; Eurofound, *Automation, digitisation and platforms: Implications for work and employment*, Publications Office of the European Union, Luxembourg 2018, p. 19

43 G. Goździewicz, '*Podstawowe zasady zbiorowego prawa pracy*' in: G. Goździewicz (ed.) *Zbiorowe prawo pracy w społecznej gospodarce rynkowej* (TNOiK 2000), p. 53.

44 OECD *Negotiating our way up. Collective bargaining in a changing world of work*, Paris, OECD Publishing, 2018, p. 233; E. Dagnino, I. Armaroli, *A seat at the table: negotiating data processing in the workplace. A national case study and comparative insights*, Comparative Labor Law Policy Journal 2020 Vol. 41, Issue 1, pp pp. 182-192.

45 World Maritime News, *Port automation friend or foe?* https://www.offshore-energy.biz/port-automation-friend-or-foe/ [access: 30.10.2020].

dam. Currently, no port in the world meets the sixth generation port criteria. Taking into account the criteria characterised by the ports of the first, second, third, fourth and fifth generation, the 6th generation ports should be distinguished by the service of container vessels with a capacity of 50 000 TEU and a maximum draft more than 20 meters[46]. As indicated above, employment in ports includes port workers such as: crane operators, industrial truck operators, construction specialists and workers, maintenance workers, dockers, equipment dispatchers and shift managers. The higher the category of port, the higher the requirements placed on those employees, who must constantly develop their skills.

What if the employee does not develop? The problem particularly affects the elderly. The younger you are, the more benefits you are likely to see in autonomous technology. Respondents aged between 25 and 44 are more likely to think that autonomous machinery could be a benefit in areas such as productivity, speed, safety, quality and fuel efficiency compared to those aged 44 and over. When it comes to job fears, it is the machine operator that is perceived to be most at risk – this is the case according to almost half of respondents (48%)[47]. Sometimes employers decide that workers who are replaced by machines must be fired. This part of the article will describe the procedure outplacement as an alternative to layoffs. Downsizing and staff reductions are common strategies for reducing business costs and improving organizational functioning. Although these strategies are often necessary for business purposes, psychological costs, such as acute stress, anxiety, and clinical depression, incumbent upon individuals being displaced, can be serious[48].

TERMINATION OF THE EMPLOYMENT CONTRACT

In order to analyze the subject of employment contract termination, it is useful to take a closer look at information about dismissals on the basis on the Polish labor law. Under Article 30 § 1(1) of the Polish Labour Code, parties to a contract of employment are entitled to freely terminate such a contract as a result of a bilateral legal act, effective upon mutual declaration of the employee and the employer aimed at termination of the employment relationship in a specified manner and within a prescribed time-limit[49]. Undoubtedly, the provisions

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46 A. Karaś, *Smart Port as a Key to the Future Development of Modern Ports*, Volume 14, Number 1, March 2020 p. 28.

47 Advancing Automation*: Workers Worry More About Site Safety Than Losing Their Jobs*, ROCKproducts September 2019, p. 18, http://rockproducts.com/.

48 J. D. Westaby, *The impact of outplacement programs on reemployment criteria: a longitudinal study of displaced managers and executives*, Journal of employment counseling, March 2004, vol. 41, p. 19.

49 D. Dörre-Kolasa, *Outline of the Polish labour law system*, edited by Krzysztof W. Baran, Warszawa 2016, p.168.

of the Labour Code aim to protect the weaker party in the employment relationship. The protective function of labour law is also fulfilled by the provisions governing collective redundancies procedure. According to Article 2 of the Act on collective redundancies[50], an employer planning mass layoffs should inform trade unions thereof in order to carry out consultations. The main purpose is to reduce the number of redundancies and mitigate the related tensions in the workplace. The contract is terminated as a result of the notice given by the employer[51].

On the other hand, attention should be drawn to Article 10 (1) of the Act on collective redundancies, according to which individual redundancies for reasons not attributable to employees shall occur only when such reasons are the only ones justifying termination of the employment relationship. Therefore, in case of refusal to accept the new proposed terms and conditions, individual and collective dismissal is final parting with the employee.

However, in certain cases automation can be a source of new jobs. As one industry becomes more productive, other industries, ie. those which use that particular industry's product as an input, will also demand more, and as a result more labor demand will appear there[52]. The loss of hundreds of thousands of jobs in the oil and gas industry has been devastating, both for the employees whose jobs were cut, and to the organisations that will probably need to rehire talents again at a later point in time. Outplacement is an option for protecting the future of a workforce. Primarily, outplacement helps employees land new jobs quickly once they have been laid off. Assisting employees to acquire new jobs helps an organisation preserve their brand by reducing the negative sentiment employees may feel upon being laid off. Retention and productivity are improved by showing the remaining workers that the company has an interest in taking care of their former coworkers (and by extension, themselves), and creates opportunities for rehiring when economic and business circumstances change[53]. An employee is entitled to unemployment benefits if he or she loses work involuntarily. Termination of an employment relationship with mutual agreement does not guarantee a dismissed employee the right to claim unemployment benefit, due to the fact that he/she together with his/her employer was made responsible for termination[54].

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50 Act of 13 March 2003, Journal of Laws 2003 no. 90 item 844.

51 Judgments of the Polish Supreme Court (SN) of 14 April 2008, II PK 362/07, LEX no. 837062 and of 17 October 2006, II PK 35/06, LEX no. 950619.

52 M. Krakovsky, *The New Jobs As automation takes on more and more tasks, what will human workers do?*, January 2018 | vol. 61 | no. 1, p. 22.

53 S. Sathe, *President and CEO RiseSmart, San Jose, California, Three ways to protect the future of your workforce, Hydrocarbon Processing*, March 2017, p. 25.

54 A. Świątkowski, *Termination of Employment Relationship: The Legal Situation in Poland*, p. 11, file:///C:/Users/ewasl/Downloads/report_poland_en.pdf [access: 30.10.2020].

OUTPLACEMENT PROCEDURE

The employer can help employees by implementing an outplacement procedure instead of group or individual layoffs justified by automation. An interesting holistic outplacement model consists of three practical elements: regaining equilibrium, career development, and job hunting. The first stage, regaining equilibrium, involves the psychological trauma of change through which the candidate must work. After candidates have regained their basic coping skills, they move into the second stage of the model: career development. The individual moves on to four traditional career planning steps: assessment, career exploration, career decision making, and action planning. In the third element of this model, job hunting, candidates develop their networking, negotiating, and influencing skills through small group discussions, role plays, and stress reducing exercises[55]. A slightly different model aims at keeping stress at mid-level and focusing on career development; yet another is made of five functions: relief, projection, enlightening direction, specification, and change of perspective. Finally, a frequently used solution is based on career development life cycle, life style change life cycle, and life style habits in unison with career change. This model consists of factors such as: loss, grief and change, personal development, job search, and continuous consultation and support. Scott and Kleiner's Loss Analysis Model consists of three parts. In first part, candidates face shock and lack of trust. In the second stage grief and anger can be experienced. The individual may feel worthless. The third factor is the realization when the individual was forced to leave coming with the experience of deep hurt and grief. Outplacement requires a very wide psychological study. In Goffman's Consolation Model, if an individual has done something wrong against someone, outplacement will aim at appeasing the other party, so that the individual is not disturbed at a later time. Meyer and Shadle's three phases Outplacement Model borrows all topics from the preceding models, with every phase made up of many steps[56].

CONCLUDING REMARKS

Automation in ports is particularly advanced, although recent studies find that a majority of construction workers are confident that AI would not do a better job (58%)[57]. On the other hand, there has been considerable pressure

[55] T. M. Aquilanti, J. Lerox, *An integrated Model of Outplacement Counseling, Journal of employment counselling*, December 1999, vol. 36, p. 182.

[56] F. Kanbur, S. Børgün, *Application of the Outplacement Model "Fatra"* To Taf Pms 2010 Concept, Journal Of Aeronautics and Space Technologies, January 2008, vol. 3 Number 3 (61-74), p.62.

[57] Advancing Automation: *Workers Worry More About Site Safety Than Losing Their Jobs*, ROCKproducts, September 2019 , p. 18, www.rockproducts.com [access: 30.10.2020].

for greater labour market flexibility, as a result of the 2008-2015 crisis. Over this period, numerous countries witnessed significant lay-offs and increasing instability of employment. Many of them adopted reforms of employment protection legislation (EPL), in the hopes of boosting employment creation and reducing unemployment, especially amongst most vulnerable groups [58].

There is no doubt that employees should improve their qualifications and there are many opportunities in this regard. However, lifelong learning is one thing and another is the pressure exerted by the trend of robotization that forces change. As indicated previously, current positons in ports include e.g. crane operators, industrial truck operators, construction specialists and workers, maintenance workers, dockers, equipment dispatchers and shift managers[59]. They must constantly keep up with changes and technological progress. The port is a diverse area, all activities must take place at the terminal level and at the port level. Implementations based on the concept of a smart port should bring benefits to stakeholders and to port authorities. While the market is full of technologies and many of them have universal applications, ports are diverse in their activities and usually need custom-made solutions[60]. Therefore, it is important that terminal and port authorities should cooperate to implement the appropriate tools alongside employee representatives, in particular trade unions.

The 'model' employer aspiring to retain the workforce in which he or she has invested will continue fair dismissal practices, regardless of the law[61]. Though handling the concerns of the remaining employees is extremely important to a downsizing company's future profitability, in terms of post-termination costs to the company, dealing with the psychological issues of the discharged employees is perhaps even more important. Former employees may be angry and could file wrongful termination lawsuits, leading to huge costs and bad press for the former employer. As organizational change becomes more prevalent, ex--employees become more eager to choose litigation[62]. Whatever the choice to support employees during these times of transition, options do exist. A proactive

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58 Employment protection legislation: summary indicators in the area of terminating regular contracts (individual dismissals) / International Labour Office, Inclusive Labour Markets, Labour Relations and Working Conditions Branch (INWORK). – Geneva: ILO, 2015, p. iii, https://www.ilo.org/wcmsp5/groups/public/—ed_protect/—protrav/—travail/documents/publication/wcms_357390.pdf [access: 30.10.2020].

59 World Maritime University, *Transport 2040*, p. 85.

60 A. Karaś, *Smart Port as a Key to the Future Development of Modern Ports*, Volume 14, Number 1, March 2020 p. 28.

61 M. Pittard, B*ack to the Future: Unjust Termination of Employment Under the Work Choices Legislation Faculty of Law*, Monash University Research, Paper No 2006/51, February 2008, p. 241.

62 J. A. Challenger, *Return on investment of high-quality outplacement programs*, 2Q/2005, Economic Perspectives Federal Reserve Bank of Chicago, p. 89.

approach and an efficient mix of short-term and longterm skills transfer and outplacement support are capable of ensuring an organization's workforce success, even in the toughest of economic times[63].

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MARINE AND COSMIC INSPIRATIONS FOR AI ALGORITHMS

Abstract One of the important areas of Artificial Intelligence (AI) algorithms applications are optimisation problems. Authors of such algorithms have various inspirations. Probably the most commonplace is the nature. For example, Artificial Neural Networks were inspired by human brain and nervous system structure while Genetic Algorithm was inspired by the biological evolution process. Amongst AI algorithms used in optimisation, a particularly large and still broadening group are swarm intelligence algorithms. These algorithms are based mainly on observations of social and food searching behaviours of various species for example birds, ants, fish, bats, bees and many other. There are also other algorithms that implement physics laws, for example laws of gravity, or environmental phenomena like hydrologic cycle, water evaporation etc. Despite large number of swarm intelligence algorithms, there is not a single ultimate algorithm that solves all types of problems (single- and multi-objective, uni- and multi-modal, with and without boundaries, etc.). Thus, there is a permanent need for new algorithms with new, original inspirations, even though some of the algorithms of this class already gained wider recognition (for example Artificial Ant Algorithm and Particle Swarm Optimisation). In the paper, a short review is presented of selected interesting swarm intelligence optimisation algorithms that draw inspirations from marine nature and cosmic space. These are: Gravitational Search Algorithm, Artificial Fish Swarm Optimization, Krill Herd, Whale Optimization Algorithm and Salp Swarm Algorithm.

Keywords: Artificial Intelligence, Swarm Intelligence, optimisation algorithms, Gravitational Search Algorithm, Artificial Fish Swarm Optimization, Krill Herd, Whale Optimization Algorithm, Salp Swarm Algorithm

INTRODUCTION

Artificial Intelligence (AI) is a scientific area that currently sees an enormous growth. Various new algorithms and methods are developed and many of them have successful practical applications. Authors of new algorithms have

diverging inspirations. Probably the most common one is the nature. For example, Artificial Neural Networks were inspired by the structure of human brain and nervous system while the classic Genetic Algorithm was inspired by the biological evolution process. One of the important areas of AI algorithms' applications is the solution to optimisation problems which can be encountered in practically all fields of science, technology and everyday life. Amongst AI algorithms used to solve optimization problems, especially large and still broadening group are swarm intelligence algorithms. They are nature-inspired, meta-heuristic algorithms which usually solve optimisation problems by mimicking biological or physical phenomena. They are based mainly on observations of behaviours of various species of animals, for example: birds[1], ants[2], grasshoppers[3], bees[4], bats[5], wolves[6], fish[7], dolphins[8] and many other, or implement physics laws or environmental phenomena like laws of gravity[9], motion of galaxies[10], lightning formation[11], hydrologic cycle[12], water evaporation[13], etc.

The general advantages of swarm optimisation are: simplicity, easy implementation and the lack of the objective function gradient information requirement. They are usually fast-converging and can bypass local optima. Despite large number of algorithms there is no single ultimate algorithm that solves all types of

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problems (single- and multi-objective, uni- and multi-modal, with and without boundaries, etc.). Thus, there is a permanent need for more algorithms with new, original inspirations.

The paper presents general advantages of swarm intelligence algorithms and a short review of selected, interesting optimisation algorithms that draw inspirations from marine nature and the outer space. These are: Gravitational Search Algorithm, Artificial Fish Swarm Optimization, Krill Herd, Whale Optimization Algorithm and Salp Swarm Algorithm.

1. BASIC CHARACTERISTICS AND APPLICATIONS OF SWARM INTELLIGENCE

Swarm intelligence is defined as a collective behaviour of decentralised, self-organised systems, natural or artificial. The most important feature of these systems is that they are composed of many, usually identical individuals and there is no centralised controller or supervisor to the whole swarm. Each individual in the swarm follows quite simple rules and can perform elementary operations. One individual is not able to solve the problem but thanks to interactions with other individuals and the environment, the whole swarm is able to "intelligently" find the solution.

Swarm algorithms usually find optimal or close to optimal solutions in a relatively short time and with relatively small computational effort. They do not depend on gradient information of the objective function (as opposed to many classic optimisation algorithms) and show the ability to solve complex, non-linear, high dimensional problems. Some of them even allow for changing the objective or problem parameters during the search for a solution, which can be useful, for example, when performing tasks in a changing or non-stationary environment. Another advantage is the possibility to stop the search in any moment, however, although the result will obviously not be optimal in this case, it will likely be better than in the initial step. Although Swarm Intelligence algorithms are usually applied for optimisation problems in virtual, computational environment (for example in extrema search, design optimisation, production planning etc.) they may be also applied to control drones, robots, groups of various objects, group navigation, formation maintaining, etc. in the real world. Some examples are: swarms of boats tested by US Navy[14], trajectory planning of a wheeled robot[15], control of

[14] J. Hsu, U.S. Navy's Drone Boat Swarm Practices Harbor Defense, IEEE Spectrum, 2016, https://spectrum.ieee.org/automaton/robotics/military-robots/navy-drone-boat-swarm-practices-harbor-defense, (Access: 20.02.2021)

[15] X. Zhang, Y. Huang, Y. Rong, G. Li, H. Wang, C. Liu, Optimal Trajectory Planning for Wheeled Mobile Robots under Localization Uncertainty and Energy Efficiency Constraints, Sensors, vol. 21, 2021, 335

space satellite swarms[16], cooperation of simple robots[17] or moving target search using UAVs[18].

One of the advantages of using swarms in the real word is that they are constructed from simple, generally small, cheap units. This means that all the benefits of mass production could be achieved, allowing for reduction of manufacturing and maintenance cost. Additionally, swarm solutions scale easily and have intrinsic parallel processing capabilities. Adding more units to the swarm does not require the change of rules or control algorithms. The same applies to reduction (of course to some limit) of the number of units. When a swarm member is lost or destroyed for some reason, the rest of the swarm can still perform the task, although the efficiency of the swarm may obviously be reduced.

2. SELECTED ALGORITHMS

GRAVITATIONAL SEARCH ALGORITHM (GSA)[19]

The main principles of this algorithm are based on the Newtonian law of gravity: "*Any particle of matter in the universe attracts any other with a force varying directly as the product of the masses and inversely as the square of the distance between them*"[20]. In mathematical form this can be described as:

$$F = G\frac{M_1 M_2}{R^2} \tag{1}$$

where: F is the gravitational force, G is the gravitational constant, M_1 and M_2 are mass of the first and second particles respectively, and R is the distance between the two particles.

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16 A. Farrag, S. Othman, T. Mahmoud, A.Y. ELRaffiei, Satellite swarm survey and new conceptual design for Earth observation applications, The Egyptian Journal of Remote Sensing and Space Science, Vol. 24, 2021, pp. 47-54. Also: H. Hildmann, M. Almeidam E. Kovacs, F. Saffre, Termite algorithms to control collaborative swarms of satellites. In: Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space (i-SAIRAS 2018), i-SAIRAS 2018, Madrid, Spain, 4–6 July 2018; European Space Agency: Paris, France, 2018

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19 E. Rashedi, H. Nezamabadi-Pour, S. Saryazdi, GSA: A Gravitational Search Algorithm, Information Sciences International Journal, vol. 179, 2009, pp. 2232–22487

20 Britannica, The Editors of Encyclopaedia, Newton's law of gravitation. Encyclopedia Britannica, https://www.britannica.com/science/Newtons-law-of-gravitation. (Accessed 21.02.2021.)

Additionally, according to the second Newton's law when a force F, is applied to a particle, its acceleration a, depends only on the force and its mass M:

$$a = \frac{F}{M} \tag{2}$$

A generalised case is shown below:

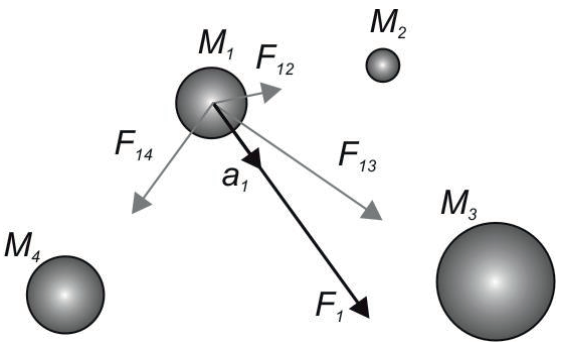

Figure 1. Forces acting on an object and its acceleration

In the GSA, possible solutions of the problem are represented as objects (search agents) and their performance is measured by their masses. All these objects attract each other, obeying the laws of gravity. Forces acting on objects cause movement of all objects in the search space. Heavier objects, which represent better solutions, move slower than lighter ones and attract lighter object stronger (with a force higher than lighter objects). Each mass (agent) is described by four parameters: position, inertial mass, active gravitational mass, and passive gravitational mass. The position of the mass corresponds to the position of the potential solution of the problem, and its gravitational and inertial masses are determined using a fitness function that describes the problem being solved. The whole system of masses reassembles a small artificial universe with stars, planets and comets that travel through space, obeying two principal laws:

- Law of gravity – similar to Newton's law of gravity, however, instead of R^2, R is used in (1) as it appeared to give better algorithm performance.
- Law of motion – the current velocity of any mass is equal to the sum of the fraction of its previous velocity and the variation in the velocity. Variation in the velocity or acceleration of any mass is equal to the force acted on the system divided by mass of inertia, similar to (2).

Apart from above given laws, some additional rules and equations (especially for updating gravitational and inertial masses during search) are defined in the algorithm.

In the GSA, movement of each agent depends on its performance and the performance of other agents. A better solution is represented by an agent's greater

gravitational mass which has a larger effect on other agents. As a result, the agents tend to move toward the best solution. On the other hand, the inertia mass is against the motion and reduces the movement of objects. Hence, as the agent approaches the solution, it gains mass, but it slows down and thus search the space more locally. This may be considered as an adaptive behaviour.

ARTIFICIAL FISH SWARM OPTIMIZATION (AFSO)[21]

The AFSO algorithm reproduces foraging, swarming and chasing behaviours of fish. One fish is a search agent that represents a location (X_i) of possible solution to the given problem. This artificial fish receives information about surrounding environmental through visual perception. While making a step, the fish seeks for food in a limited visual range (V_r) by checking the value of a fitness function $Y = f(X_v)$ (equivalent of food density in real life). If the Y value at the visual position Xv is better than in the current position X_i, it goes forward a step in this direction to the X_n position (figure 2). Otherwise, it continues random search around X_i. The search behaviour is also affected by the number of other fish in visual range. If this number is below a threshold, which means that visual scope is not crowded, the fish moves toward the centre of the local swarm (formed from fish visible in the visual range) if the Y value is better there, or towards the fish representing the best solution (neighbouring fish with the best Y), depending on which is better; or it moves randomly if above criteria are not met. If the number of fish in visual range is too high (neighbourhood is crowded), the fish also performs a random search step.

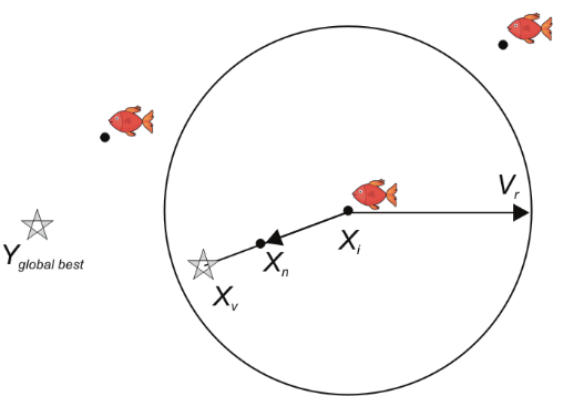

Figure 2. Artificial fish and its environment

[21] L.X. Li, Z.J. Shao, J.X. Qian, An Optimizing method based on autonomous animals: fish-swarm algorithm, Systems Engineering – Theory Practice, vol. 22, no.11, 2002, pp. 32-38. Also: M. Neshat, A. Adeli, G. Sepidnam, M. Sargolzaei, A. Najaran Toosi, A review of artificial fish swarm optimization methods and applications, Int. Journal on Smart Sensing and Intelligent Systems, vol. 5, 2012, pp. 107-148

After its initial publication, the AFSO algorithm quickly gained recognition and various applications. Many improved versions have been proposed as well[22]. The algorithm has high convergence speed, is flexible and has good error tolerance.

KRILL HERD (KH)[23]

This algorithm takes its origin in observations of arctic krill and the way it forms large swarms. The three main actions are represented in the algorithm: movement induced by other krill individuals, foraging and random diffusion. The first one defines the direction of krill individuals (search agents) motion and consist of the effects of local swarm density (local effect), a target swarm density (target effect) and a repulsive swarm density (repulsive effect). The effect of the neighbours acts as an attractive/repulsive tendency between the individuals for a local search. Neighbours and its number can be identified in various ways. The simple way is to use "sensing distance" around the krill individual (figure 3).

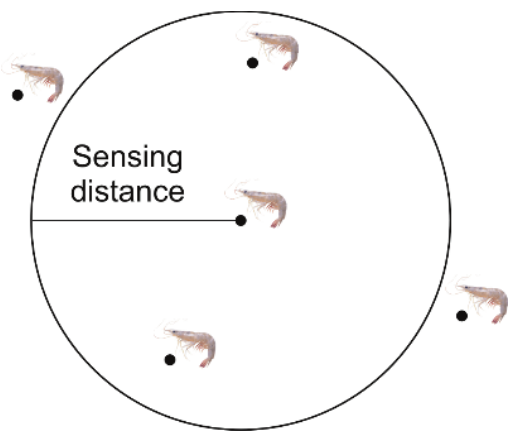

Figure 3. Neighbours identification in Krill Herd Algorithm

The foraging motion is calculated according to the food location and the motion calculated in the previous movement step. The food location is estimated according to fitness function values of the krill individuals, for example using the "centre of mass" idea. The third element of krill movement is physical diffusion which is a random process. However, as the algorithm progresses, the influence of this random element is gradually reduced. All of these actions work in parallel. Individuals that have better fitness values attract other krill while individuals with

[22] Ibid.

[23] A. H. Gandomi, A. H. Alavi, Krill herd: A new bio-inspired optimization algorithm, Communications in Nonlinear Science and Numerical Simulation, vol. 17, issue 12, 2012, pp. 4831-4845

worse values – have repulsive effect. Additionally, the KH algorithm can be improved by adding the mechanism of crossover and mutation known from genetic algorithms.

The KH is a sophisticated and efficient algorithm. An interesting fact is that values of various hyperparameters were set by KH authors according to the results of studies on the real arctic krill behaviours. Another distinctive property of the algorithm is that the global best result is estimated as the centre of food determined according to the fitnesses of all of krill individuals. Usually, in other algorithms, the best solution is simply the best result obtained by one of the search agents.

WHALE OPTIMIZATION ALGORITHM (WOA)[24]

Whale Optimization Algorithm, as its name suggests, was inspired by humpback whales hunting technique called „bubble-net method". During the hunt, whales approach swarms of krill or small fish in a spiral path, starting a dozen of meters under the water surface and then gradually approaching the surface. When circling, humpbacks create air bubbles which force prey to concentrate in the middle of the circle (figure 4).

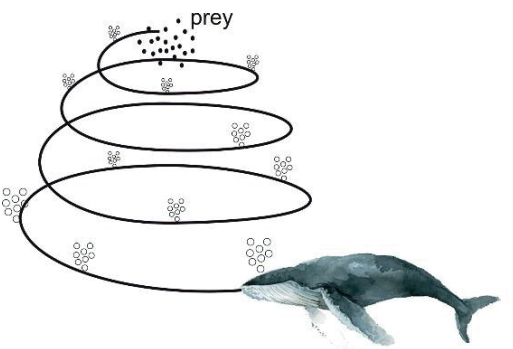

Figure 4. Bubble-net spiral attack behaviour of humpbacks.

Those strategies of encircling and bubble-net attacking are represented in WOA. Additionally, random search for food is implemented. The following equations describe the encircling strategy, and the agent's moves are performed around the current best result:

$$\vec{D} = \left| \vec{C} \cdot \vec{X}^*(t) - \vec{X}(t) \right| \tag{3}$$

[24] S. Mirjalili, A. Lewis, The Whale Optimization Algorithm, Advances in Engineering Software, vol. 95, 2016, pp. 51-67

$$\vec{X}(t+1) = \overrightarrow{X^*}(t) - \vec{A} \cdot \vec{D} \tag{4}$$

$$\vec{A} = 2\vec{a} \cdot \vec{r} - \vec{a} \tag{5}$$

$$\vec{C} = 2\vec{r} \tag{6}$$

where: t indicates current iteration number, $\vec{A}$ and $\vec{C}$ are coefficient vectors, $\vec{X}$ is the agent's position vector, $\vec{X}^*$ is the position vector of current best solution, $\vec{a}$ is coefficient linearly decreased from 2 to 0 along the course of the algorithm, $\vec{r}$ is a random factor with uniform distribution in the range <0,1>.

However, if the value of $|A| \geq 1$, current best result $\vec{X}^*$ is replaced in (3) and (4) by the position of randomly selected, other agent $\vec{X}_{rand}$. This favours the exploitation of search space as in the initial phase of the algorithm it is likely that the circle will be broadened. As the algorithm progresses, the broadening of the circle is less likely to happen than shrinking. At the same time, the spiral deterministic move can be performed by the search agent. This is described by the equation:

$$\vec{X}(t+1) = \left|\vec{X}^*(t) - \vec{X}(t)\right| \cdot e^{bl} \cdot cos(2\pi l) + \vec{X}^*(t) \tag{7}$$

where: b is a constant defining the shape of the logarithmic spiral and l is a random factor with uniform distribution in the range <0,1>.

The decision of selecting encircling or spiral move is chosen randomly.

Despite being a relatively new algorithm, WOA already found many practical applications in various engineering fields and multidisciplinary problems[25]. This is probably mainly due to its relative simplicity, fast convergence and providing a good balance between exploration and exploitation.

SALP SWARM ALGORITHM (SSA)[26]

Another inspiration for swarm intelligence algorithm came from salps. Salps are barrel-shaped, gelatinous organisms that move by pumping water through their bodies which is an example of natural jet propulsion. They are common in oceans around the world. Salps may live alone but often form long, stringy colonies. The SSA is a very simple yet effective algorithm. It reflects two social

[25] N. Rana, MSA. Latiff, SM Abdulhamid, H Chiroma, Whale optimization algorithm: a systematic review of contemporary applications, modifications and developments. Neural Computing and Applications, vol. 32, 2020, pp. 16245–16277.

[26] S. Mirjalili, A. H. Gandomi, S. Z. Mirjalili, S. Saremi, H. Faris, S. M. Mirjalili, Salp Swarm Algorithm: A bio-inspired optimizer for engineering design problems, Advances in Engineering Software, vol. 114, 2017, pp. 163-191

behaviours of salps: food chasing and swarming in chain-like forms. In the algorithm, a salp represents a search agent. During initialisation, agents are randomly placed in the search space. One of them is selected as chain leader moving towards the food, as in the best solution found so far (eq. 8).

$$x_l^1 = \begin{cases} F_{currentbest} + c_1((ub - lb)c_2 + lb) \ \ for \ c_3 \geq 0.5 \\ F_{currentbest} - c_1((ub - lb)c_2 + lb) \ \ for \ c_3 < 0.5 \end{cases} \tag{8}$$

where *ub* is the upper bound and *lb* is the lower bound of the search space.

This move is distorted by c_1, c_2 and c_3 coefficients. Coefficients c_2 and c_3 are random values with uniform distribution in the range <0,1>. The c_1 factor is calculated in each iteration as:

$$c_1 = 2e^{-\left(\frac{4l}{L}\right)^2} \tag{9}$$

where l is the current iteration number and L is the maximum number of iterations.

At the beginning, the value of c_1 is close to 2 and it dominates the leader moves but as the algorithm progresses, it is quickly reduced and the leader moves around current best solution in gradually smaller and smaller steps. The coefficient c_1 is the key parameter in SSA, because it balances exploration and exploitation.

Apart from the leader, all other salps move towards the proceeding salp (for example, the one with the lower index on the agents list):

$$x_l^i = \frac{1}{2}\left(x_l^i + x_l^{i-1}\right) \ \ for \ l \geq 2 \tag{10}$$

This mimics the forming of the salp chain, which follows the leader and gradually shrinks around current best solution that helps find an even better solution if it is located nearby (figure 5).

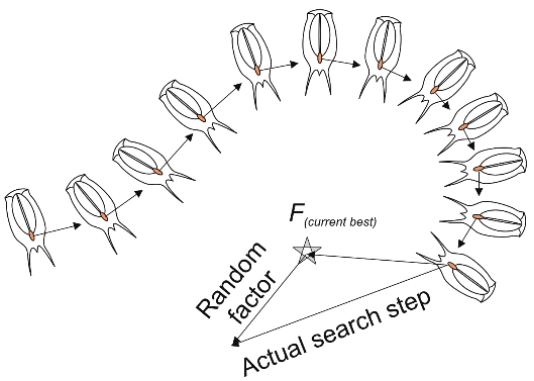

Figure 5. Salp swarm – chain forming and food chasing schematic

The SSA shows good performance in optimisation tasks also in case when optimum solution changes its location during search. A practical advantage of SSA is a small number of algorithm's hyperparameters. Additionally, those hyperparameters' values are predefined by SSA authors and there is usually no need to search for a set of these values that suits best to the particular application of SSA. Additionally, modified version of the SSA for multiobjective problems is available as well.

Although SSA was developed recently, thanks to its simplicity and desired properties it quickly gains recognition and practical applications, currently mostly in, but not limited to, energy industry and power distribution optimisation, for example: prediction of pressure burst in pipelines[27], optimization of wind turbine location[28], technical, economic and environmental optimisation of operation of power systems [29] and prediction of wind power[30].

3. SUMMARY

Selected Swarm Intelligence algorithms, that draw inspiration form marine nature or the outer space, have been briefly presented above. These are of course only some examples of a large and still growing group of swarm algorithms. Different algorithms have different efficiency for a different classes of problems and there is no one, ultimate algorithm to solve them all. Thus, there is the permanent need for new algorithms with fresh, original inspirations as well as for modifications of already developed ones. The main areas where the performance of the algorithms may be improved are: better local optima avoidance, faster convergence, reduction of the number of hyperparameters and reduction of computational complexity. Apart from basic versions of the above mentioned algorithms, there are also many modifications and hybridisation with other algorithms proposed (especially with Genetic Algorithms), examples of which are

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27 H. Lu, T. Iseley, J. Matthews, W. Liao, M. Azimi, An ensemble model based on relevance vector machine and multi-objective salp swarm algorithm for predicting burst pressure of corroded pipelines. Journal of Petroleum Science and Engineering, vol 203, 2021.

28 S. Settoul, M. Zellagui, R. Chenni, A New Optimization Algorithm for Optimal Wind Turbine Location Problem in Constantine City Electric Distribution Network Based Active Power Loss Reduction, Journal of Optimization in Industrial Engineering, vol. 14, 2021, pp. 13-22.

29 R.A. El Sehiemy, F. Selim, B. Bentouati, M.A. Abido, A novel multi-objective hybrid particle swarm and salp optimization algorithm for technical-economical-environmental operation in power systems", Energy, vol. 193, 2020.

30 L. Tan, J. Han, H. Zhang, Ultra-Short-Term Wind Power Prediction by Salp Swarm Algorithm-Based Optimizing Extreme Learning Machine, IEEE Access, vol. 8, 2020, pp. 44470-44484.

presented by Gandelli et al [31] and by Nawiis et al.[32], whose works are worth mentioning here, but they fall outside the scope of the present article.

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THE IMPACT OF „INDUSTRIAL REVOLUTION 4.0" ON THE DEVELOPMENT OF PORT TRANSPORT HUBS

... "People want progress but do not want changes" ...
(Søren Kirkegaard 1813-1855)

Abstract: The contemporary world is faced with many complex and interrelated phenomena and trends, defined as globally significant changes or as trends transforming society and posing challenges for all spheres of economic and social activity. The accumulation of such phenomena is seen as the turning point of a civilization, i.e. the replacement of a shrinking industrial civilization by another one, even if still undefined in the absence of intellectual concepts pertaining to solve significant structural problems. Such social attitude towards the past is a reaction of people to rapid and profound changes that they are unable to understand, and consequently they return to old, known and proven behaviour[1]. In these conditions, the process of shaping a new reality begins. It is referred to as the 4th industrial revolution, which aims to combine qualitatively different material and digital resources in a way that will allow us to understand the new technological revolution and properly direct its course[2]. Economic activity is particularly susceptible to these type of changes, including the transport sector, which is already undergoing radical quantitative and qualitative changes. In addition, this sector has to face several fundamental challenges resulting from the crisis of globalization and from the future concept of sustainable and environmentally friendly development of a globally managed economy.

Keywords: globalization, 4th industrial revolution, port transport hubs, challenges.

1 See: Z. Bauman, *Retropia. Jak rządzi nami przeszłość,* Wydawnictwo Naukowe PWN, Warszawa 2018, pp. 18-19.

2 See: K. Schwab, *Czwarta rewolucja przemysłowa*, Wydawnictwo Studio EMKA, Warszawa 2018, pp. 22-25.

1. THE ESSENCE AND CONDITIONS OF THE FOURTH INDUSTRIAL REVOLUTION

Revolution equals sudden and radical change. The most dynamic drivers of economic and social changes in the past centuries were inventions related to tools and methods of production[3]. New technologies are also new ways of perceiving the world that represent a fundamental change in economic systems and social structures. The fourth industrial revolution is the latest phase of the development of globalisation, most often understood as the process of establishing, tightening and multiplying economy-wide economic, political and socio-cultural ties[4]. This development is dominated by continuous, and occasionally accelerating, technical progress. Within the development of globalisation, we can distinguish four stages, referred to as successive types of industrial revolution.

The first industrial revolution began around mid of 18th century and lasted until the mid of 19th century. Its basis was the Promethean innovation in the form of a steam engine capable of converting the energy contained in coal into useful work. In addition, thanks to the telegraph, international trade, capital and labor flows significantly accelerated. The use of steam engine revolutionised transport, enabling mass transport of goods and people by rail and ship, and created an international market for raw materials. It also enabled the transformation of manual handcraft into industrial activity.

The second industrial revolution was based on the use of electricity, resulting in the creation of the electric motor, light bulb, tram and metro, radio, the development of the internal combustion engine and the application of an assembly line and serial production in factories. This contributed to a significant increase in the welfare of many social groups in economically developed countries, as well as to the expansion of the scope of consumption and the emergence of a market for perishable food products. It happened thanks to the introduction of cold storage. Due to the pro-consumer nature of this stage of the industrial revolution, it is often referred to as the time of satisfaction and prosperity. It lasted from the end of the 19th century to the beginning of 20th century (First World War).

The third industrial revolution took place in the period 1945-1980. This period saw great progress in the field of information technology and telecommunications. The development of computers and the wide use of television, including satellite and mobile phones, was also of key importance. It is popularly called the computer or digital revolution, as the catalysts of progress were semiconduc-

[3] See: R. Cameron, *Historia gospodarcza świata. Od paleolitu do czasów najnowszych*, Wydawnictwo Książka i Wiedza, Warszawa 1996, p. 16.

[4] See: H.R. Nau, *Perspective in international relations. Power, institutions and ideas*, Washington 2007, pp. 9-27.

tors and large computer systems, personal computers and the Internet. In addition, three significant innovations in transport were applied: containers, jet airliners and tankers.

While previous industrial revolutions were characterised by a relatively slow introduction of breakthrough technical innovations, allowing man to adapt to the new reality, the 4th industrial revolution constitutes a qualitatively and mentally new challenge to human adaptation. The 4th industrial revolution is in fact the unification of the world of real production machines, with the virtual world of the boarding school and information technologies. It is a specific integration of man and machine or machines.

There is no clear cut-off between the 3rd and 4th industrial revolution. The economic essence of the fourth industrial revolution can be interpreted as a fusion of products and services, as well as individualisation of production by integrating the customer's expectations within the manufacturer's offer. The fourth industrial revolution is associated with the digitization and networking of value-added chains, from design and research, through production, management and logistics, to the distribution of final goods. The essence of this revolution "…is the transfer of most decisions from the hands of people to the competence of machines and the blurring of the boundaries between what is biological and what is digital…"[5].

The concept of the "Revolution 4.0" will permanently change how we manage the economy and will have a fundamental impact on international socio-political relations. It will touch on every aspect of human existence – work, health, interpersonal relations or the culture of everyday life. The fourth industrial revolution is based on the application of intelligent and inclusive technology, within any organisation but also, more and more pervasively, in everyday life. The main driving forces behind these changes are: artificial intelligence and learning machines, Internet of Things, blockchain, autonomous vehicles, 3D printing and advanced robotization.

Huge amounts of systematically growing data generated by control systems, currently used mainly to monitor technological processes, will in the future make it possible to predict behavior and enable effective management on a global scale. Communication technologies between machines, business entities and consumers based on the industrial use of the Internet, as well as advanced methods of information processing, are a key factor of transformation from "Revolution 3.0" (introduction to the computer industry and automation of manufacturing processes) to "Revolution 4.0". The main feature in this case is not the transition to higher and higher stages of development, but the shape, pace, nature, intensity and direction of these transformations. It is based on human innovation as a resource that cannot be exhausted, and thus allows us to reject defeatist thin-

[5] K. Schwab, *Czwarta rewolucja przemysłowa*, Wydawnictwo Studio EMKA, Warszawa 20118, p.14.

king about the existence of limits to development. Revolution 4.0 offers new Promethean technologies, i.e. those that represent a civilization leap in the way of producing and using energy that is the basis for the functioning of any complex system, including the economy and civilization. Transport plays an important role in the fast and successful course of this process, as each industrial revolution requires changes in four basic areas of the economy: technology, energy, transport of goods and communication.

2. CONTROVERSIAL GLOBALISATION

Globalisation is a multifaceted mega-trend of world development. Its driving forces are primarily technical and economic progress, and its consequences in the socio-political sphere. It is long-lasting and spontaneous, and its appearance is not a product of the 20th century[6]. The first clear manifestations of this process can be observed already from the era of great geographical discoveries, and then as the effects of the industrial revolution of the nineteenth century and, more recently, the information technology revolution. What all these eras have in common is technological progress advancing in waves, raising productive forces and social relations to a significantly higher and qualitatively different level.

Generally speaking, globalisation is a set of processes that co-organise a common world. Today, globalisation is understood as the process of liberalisation of relations and the accompanying integration of previously largely isolated national economies, into one interconnected world market. As a result, the importance of national borders is gradually fading, while integration covers the spheres of national economies, trade and international investment, production, technology and technology management, cultures and socio-political relations. The consequences of this are increasingly complex relations and growing interdependencies between states[7].

The globalisation process, viewed in a perspective, began to play a key role in the shaping of the world economy from the mid-1980s. The effect of rapidly advancing globalisation over the next quarter century were mainly positive and they covered the following areas:

- systematic development of world production,
- increase in international economic cooperation manifested in the growth of the volume of international trade and a marked acceleration in direct foreign investments,
- globalisation of financial markets,

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6 See: G. Kołodko, *Globalizacja, kryzys i co dalej*, Wydawnictwo POLTEXT, Warszawa 2010, pp. 7-14.

7 E. Skawińska, P. Kułyk, A. Niewiadomska, *Międzynarodowe stosunki gospodarcze. Poszukiwanie równowagi*, Wydawnictwo CeDeWu, Warszawa 2018, pp. 19-51.

- the progressive internationalisation of production and development of global value chains,
- rapid and creative scientific and technical progress,
- intensification of international migrations,
- other emerging forms of economic ties.

It seemed that globalisation was an objective, self-contained and continuously progressing process. It will continue to create primarily positive effects, as the networks of international economic ties have exceeded their critical mass. This will cause further progress of globalisation, and stimulate the formation of new ties.

Since the beginning of the second decade of the 21st century, the world economy has faced complex challenges to its developments that need resolving. These mutually dependent challenges are not yet direct threats, but they do require analysis and constructive assessment and then pre-emptive action to solve them[8]. The most important challenges are:

- decline in the rate of economic growth,
- pressure of growing public debt,
- demographic changes and aging populations,
- depletion of resources,
- deepening economic and social inequalities,
- global migrations,
- mitigating the impact of technical progress,
- digitization of economies and societies
- climate and environmental changes,
- strong increase in international competition,
- shifting the center of world economic power,

This was also clearly revealed by the COVID-19 pandemic[9]. Breaking down these complex barriers to development is critical to the future development of the global economy. Its sudden collapse in 2008 started a wide and protracted recession, with impacts beyond the area of economic relations. Consequently, since then globalisation has decelerated and this stage is often referred to as „slowbalisation"[10]. In addition, there is evidence of the deglobalisation of the world economy. Deglobalisation is a reaction to the current form globalisation, which on the one hand is synonymous with the dynamic development of international trade, and on the other hand, corporate globalism motivated by profit above equality, justice, natural environment, solidarity and social welfare[11]. Deglobali-

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8 E. Bendyk, *W Polsce, czyli wszędzie, Rzecz o upadku i przyszłości świata*, Wydawca 'Polityka" Sp. Z o.o, Warszawa 2020, pp. 52-66.

9 A.J. Ali, *Global challenges: the pressing and visible issues*, „Competitiveness Review" Nr 3/2014, p.192-198.

10 P. Falfas, A. Odrobina, *Syndromy spowolnienia globalizacji (slowbalisation*, [w] Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2020, p.107-131.

11 G. Ziewiec, *Trzy fale globalizacji. Rozwój, nadzieje i rozczarowania*, Instytut Nauk Politycznych PAN, Warszawa 2012, p. 192-206.

sation will mainly alter the functioning of value chains, causing excessive fragmentation of international production. Fragmentation of production is also seen as a significant cause for the collapse of world trade, as evidenced recently by the COVID-19 pandemic.

The decline in the importance of nation-states, the growing importance of international corporations and the current state of globalisation create the problem of financing the revolution 4.0. Up to now, it has usually been the state that had an interest in the development of new technologies, both for military and industrial-political reasons. This state financed basic research, where commercial interests were not the main priority. As a consequence, the research results were often transferred "for free" to international corporations. The crisis of the global economy itself changes the relationship between the creators of technological progress, its financing and progress itself. As a result, although the development and implementation of new technical innovations is necessary, it becomes more and more unpredictable.

3. PORTS AS TRANSPORT HUBS UNDER THE CONDITIONS OF "REVOLUTION 4.0"

The "4.0 revolution" is irrevocably linked with growing production and expanding range of locations for entities that make up the production value chain. As a result, there is a strong increase in the demand for the transport of cargo of decreasing size. This, combined with the increase in quality requirements for supply and distribution systems, requires reliance on time-effective and cost--effective and flexible logistics and transport. This is commonly referred to as "Transport 4.0" and represents the direct impact of the fourth industrial revolution on international freight and passenger transport.

The "4.0 Revolution" is increasingly dependent on safe, ecological and efficient transport. When holistically managing transport, transport infrastructure and cooperation economic entities must adapt fixed assets, develop innovative transport technologies and prepare new management models.

"Transport System 4.0" includes all elements directly and indirectly related to the movement of cargo and passengers. It is characterised by a specific structure and constitutes a logically ordered whole, allowing for a strong connection and coordination between all components that are part of this system and its environment. The condition for successful cooperation is openness to change and willingness to improve skills.

The focal point, where development challenges are concentrated, is the seaport, being the key link in the international transport network. It is a particularly convenient location for a wide variety of economic activities, especially transport, trade, logistics and other complementary activities. All these activities comple-

ment each other and stimulate each other's development, providing opportunities for significant added value related to the efficient and comprehensive management of cargo, passengers and the means of transport that carry them. This results from the implementation of the basic task of each seaport, which performs a leading role. Such activities are carried out through the function integrating various activities arising in connection with the development of individual types of economic activity occurring in ports, and the functioning of these ports, and between ports and their hinterland. The integrating function of a port consists of specific activities covering:

- transport and reloading function,
- commercial function,
- passenger traffic service function,
- logistics and distribution function,
- industrial function,
- city and region-forming function,
- social and civilisation function,
- administrative and political function[12].

Functions fulfilled by a particular port, its scope and size, depends on the geographical location of the port, its role in the international transport system, road, rail and inland waterway connections with the rest of the country/ market, public transport policy, the port's competitive position, as well as other relevant factors[13]. The activity of ports is influenced by both domestic and international, as well as internal factors. This will determine the future operation of the port in the conditions of the 4.0 revolution. Ports must face the problems of the future related to their sustainable development, i.e. climate change, changes to modern shipping, expectations of stakeholders, as well as the need to improve cooperation between ports, government agencies and local communities[14].

In the era of globalisation, a seaport is not only the area where land meets the sea, but a place where both ships and land transport deliver cargo. The rapidly growing volume and variety of goods handled in ports, their varied geographical origins, means that a modern seaport should not be perceived only in economic, but also in technical, social and cultural terms. It is an area of application of modern management methods. It is the basic element of the land-sea transport chain, within which the following can be distinguished:

- technical and functional transport chain,
- organisational and administrative transport chain,
- communication transport chain.

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12 See: A. Grzelakowski, M. Matczak, *Współczesne porty morskie. Funkcjonowanie i rozwój*, Wydawnictwo Akademii Morskiej, Gdynia 2012, pp. 30-32.

13 See: E. Gostomski, T. Nowosielski, *Ewolucja i znaczenie portów morskich w krajach Unii Europejskiej*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2021, pp.146-184.

14 As above, p.219.

The land-maritime transport chain is the highest form of complexity and integration of maritime transport with related diverse economic activities. The management of this extensive system in the face of globalization is possible thanks to logistics, understood as a purposefully organized and IT-supported set of activities such as supply, production, storage, transport and distribution, as well as supporting services, along with the relations between them, their properties and the constant efforts to achieve a higher degree of organisation and efficiency[15].

From the perspective of the port's development, the logistics approach to the land-sea transport chain is not limited only to the coordination and synchronization of the different phases of the transport process. It is also the technical adaptation to each other of the transport infrastructure and means of transport, handling and storage facilities, organisational integration of the coordination of activities of all participants on the surface of the sea and the interests of their internal and international environment. Significant help in this area is offered by the achievements of revolution 4.0 implemented as part of sustainable development.

It is in the seaport that most of the changes related to the 4th industrial revolution seem to concentrate, which is also commonly identified with the blended technologies of "Industry 4.0". These technologies are closely related and cooperating within the cyber-physical system. It is this system of interdependent and cooperating information technologies that generates new value for people, including economic value. Both the speed and the extent of the changes taking place, coupled with the increase in complexity, make the task of developing and implementing strategies, that promote productivity and inclusive growth, inherently difficult. It is important to build awareness of the qualitatively new factors and conditions required for the transformation of economic systems, such as a seaport, to assess their readiness to face the future challenges of the civilization crisis and the implementation of the "Industrial Revolution 4.0".

4. THE STATE OF READINESS OF THE ECONOMY TO THE CHALLENGES OF THE "4.0 REVOLUTION"

The implementation of the idea of the fourth industrial revolution creates the need for new comparative and diagnostic tools facilitating dialogue between stakeholders, shaping joint activities, informing about the development of new ideas of strategies, taking into account that what is new and unknown often creates uncertainty. Nevertheless, the fourth industrial revolution has already begun and it is impossible to ignore it. Future changes cannot be limited to

[15] See: E. Gołembska, *Logistyka,* Wydawnictwo C. H. Beck, Warszawa 2012, pp. 43-73.

technological changes, but must also take into account such fundamental issues as: changes in the ways of thinking, education, work, health, running a business, organisation, society, or the functioning of states and their economic and social potential. It is the state of economic potential and innovation of each country that determine the scope and speed of implementation of the achievements of the 4.0 revolution. A novel attempt to assess the ability of countries to adapt the economy to the requirements of the fourth industrial revolution was made for the first time in 2018 by the World Economic Forum together with the international consulting company A.T. Kearney[16]. This took the form of a country's permanent readiness index to implement the concept of industry 4.0. This index is the result of the impact of the country's economic potential represented by its complexity and size, and the impact of the state of six production development stimulators, such as:

- the potential of technology and innovation,
- the state of human capital,
- global trade and investment,
- institutional structure of the economy,
- balancing the raw material potential,
- demand potential,
- production factor potential.

This index is forward-looking and its authors have tried to combine on the one hand the size of the impact of fixed factors defined as the structure of production (complexity and size) and on the other hand six relatively permanent factors defined as production development stimulators. From the perspective of the structural aspects, the ranking of the ten leading countries in the world in terms of readiness to implement the concept of "Revolution 4.0" is as follows:

1. Japan 8.99;
2. South Korea 8.85;
3. Germany 8.68;
4. Switzerland 8.39;
5. China 8.25;
6. Czech Republic 7.94
7. USA 7.78;
8. Sweden 7.46;
9. Austria 7.46;
10. Ireland 7.34;
11. **Poland** **6.83.**

From the perspective of production development stimulators, the ranking is as follows:

[16] See: *Readiness for the future of production report 2018*, World Economic Forum and A.T. Kearney, Coloque-Geneva 2018, pp. 1-12.

1. USA 8.16;
2. Singapore 7.96;
3. Switzerland 7.92;
4. Great Britain 7.84;
5. Netherlands 7.75;
6. Germany 7.56;
7. Canada 7.54;
8. Sweden 7.40;
9. Denmark 7.20;
10. Finland 7.16;
11. **Poland** **5.83.**

The ranking covers 100 countries around the world, and the maximum possible value of the index is 10.0. Attention is drawn by the fact that the values of the indices for the structural readiness ranking are closer to maximum value than the case is for the production stimulus readiness ranking. Only four countries (USA, Switzerland, Germany and Sweden) are included in both rankings, and the composition of the lead countries confirms the intuition of the international community. The above two rankings are a point of reference and inspiration to diagnose readiness and work out an optimal method of implementing the fourth industrial revolution to national economies[17].

The fourth industrial revolution will have a fundamental and irreversible impact on economic, social and political systems. Even the slowdown or the reversal of the globalization process will not change it. It should be kept in mind that the impact of the "4.0 Revolution" on the economy is also manifested in the transition from the concept of global management to the concept of global governance. To rule is to decide by all about their common affairs by the method of continuous consensus building[18]. This is a particularly difficult task, because in the new conditions man will not be an operator, but only a supervisor of autonomous systems of devices controlled by artificial intelligence. Working with artificial intelligence, humans will need to demonstrate different thinking and reasoning skills in order to be able to oversee autonomous decisions made by independent systems controlled by artificial intelligence[19].

CONCLUSIONS

The remedy for the civilisation turning point that we are experiencing, and the further development of the world economy, is seen in the positive effects of implementing the "Revolution 4.0". This change has been made evident by the

[17] See: *Singapore smart industry readiness index. Catalysing the transformation of manufacturing*, Singapore Economic Development Board, Singapore 2017, pp. 6-38.

[18] A.M. Kjaer, *Rządzenie*, Wydawnictwo SIC, Warszawa 2009, p. 29-117.

[19] See: W. Cellary, *Przemysł 4,0 i gospodarka 4,0*, Biuletyn PTE, Nr 3/2019 p. 48-51.

current economic and financial crisis, which has its deeper source in the cultural crisis, and, in fact, in the crisis of values. This forces us to look at the world economic and social system anew, in the light of the relationship between its economic value and values important in the social and cultural dimension. This also applies to port transport hubs. Their main determinants of development lie beyond them and concern the modernity and frequency and regularity of the operation of land-sea connections, costs and quality of service, competitiveness of the offered land-sea transport services and a wide range of complementary services. In this light, it is necessary to constantly improve the infrastructure of ports leading to an increase in their capacity to handle goods and passengers, by encompassing the maritime and terrestrial environment, supported by IT and telecommunications of the 4.0 generation and artificial intelligence.

The modern economy develops in correspondence with profound social changes and is transformed by the digital technological revolution and global openness to international cooperation. As a result, it has become a space for confronting various value systems. It is this confrontation that determines the future shape of the world economy and the use of innovation as the final resource that allows us to optimistically perceive the future of world development, taking into account the political aspect of this development[20].

The future of the fourth industrial revolution on the socio-economic level requires courage, imagination, new approaches and new institutions. They must in a credible and at the same time appealing way express the meaning of the changes taking place and help regain faith in the future – a future free from fear of the unknown and rebuilding social trust.

SUMMARY

IMPACT OF „INDUSTRIAL REVOLUTION 4,0" ON THE DEVELOPMENT OF PORT TRANSPORT HUBS

The whole world is undergoing increasingly faster changes. The initial analysis indicates technological advances as a key factor. Not only are they the driving force of change in many areas of life, but they have also introduced revolutionary changes in the concepts of the operation of the modern global economy and, at the same time, maritime industry. There have been a number of new concepts, predictions and the individual actions together with the question about the directions, scope and pace of transformations in maritime industry.

One of such new considerations is the concept of „Industrial Revolution 4.0". Professor Klaus Schwab, founder and executive chairman of the World

[20] See: I. Wallerstein, *Koniec świata jaki znamy*, Wydawnictwo Naukowe SCHOLAR, Warszawa 2004, pp. 231-261.

Economic Forum, defines the 4th industrial revolution as "…new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human. Previous industrial revolutions liberated humankind from animal power, made mass production possible and brought digital capabilities to billions of people…". Despite how fast the technology in our interconnected world evolves and how fast we adopt it, the „Industry 4.0" is ultimately about people.

Therefore, it is worth examining the assumptions if this concept and the consequences of its implementation in order not only to prepare to this new reality, but also take rational measures to adjust Polish maritime industry to the new needs and challenges.

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WHY INTERNATIONAL LAW IS LESS EFFICIENT THAN DOMESTIC LEGAL SYSTEMS?

Abstract: This essay argues that international public law is less efficient and less culturally adequate than domestic legal systems. There are many reasons for operational deficiencies of international law, such as the impossibility of full cultural adequacy of international law because there are too many and too different cultures on the Globe, and the strategic power game of superpowers that leads to frequent acts of strong states, which disregard the international law without being punished for this. I have focused on a purely legal premise of lower efficiency of international law, however. The very loose structure of sources of international law and the lack of strong enforcement of legal norms are presented as the main reason for the functional weakness of international law and some recommendations are proposed to make this variety of law as strong as necessary in the next stages of globalisation. The more global the scope of problems that humankind is confronted with, the stronger the authority and systemic efficiency of international law should be. At present, unfortunately, it is not culturally adequate and needs comprehensive reform. Without smart and comprehensive reform, international law may become obsolete in times that need its authority much more than any other era in human history.

Keywords: sources of law, systemic efficiency of law, cultural adequacy of law. authority of law.

1. LEGAL SYSTEM: ITS CULTURAL ADEQUACY AND SYSTEMIC EFFICIENCY

The legal concept that we need to be able to compare efficiency of regulative capacities of international and domestic legal systems should be universal enough to describe what are common and what are specific characteristics of legal systems under study. Common features of legal systems are the following:

- Any law is a system created or recognised by humans for the humans who are present on the relevant territory. Legal systems are the streamlined

configurations of social facts, such as human interactions which generate the process of emergence of valid norms of conduct[1].

- The groups in power at a given moment may enact the laws by legislative authority within specific states or just recognise some longstanding customs as binding, valid and worthy of being enforced. International law is made by contracts or agreements between at least of two actors.
- The law is a system of rules and principles of conduct. Its fundamental and primary purpose is to regulate modes of conduct of any person or organisation in such a way that facilitates cooperation, or at least reduces the conflict of interests. No single and singular legal rule or principle can regulate the conduct of individuals or organisations.

Only dynamic interactions of valid norms and cooperation of many relevant legal norms in conjunction with facts may have the power and authority to regulate the conduct of any subject under a specific legal system. The system regulates because it is a system and a singular norm that belongs to this system is inefficient without necessary cooperation with many other norms that belong to this system.

Systemic efficiency of international law is less feasible than systemic efficiency of domestic law because of many reasons but the fundamental reason is well known – systemic emergence of social power in the international community is much harder to produce than in conditions of a specific state and its legal system. Normative legal systems are binding on all subjects on equal terms and nobody should be identified as homo sacer, the outlawed person orone that shall not be protected by the law and shall have no rights and duties under this law.

This means that the efficiency of law is a complex matter referring to the cultural adequacy of legal systems and different styles of *executio iuris* in the broad sense. The more adequate is an operating legal system and the higher are its capabilities to adapt to dynamic conditions, the higher could be its capability to regulate behaviours and social processes. Adaptations of legal systems must be flexible and smooth enough to be able to:

- address the pressing social needs of nations and civil societies;
- foster the civilisational development of contemporary societies and cultures;
- serve the interests of the dominant groups without ignoring the interests of non-dominant groups;
- be consistent with the level of development of a society or societies;
- express the values shared by majorities and to protect the values of many minorities living under a legal system;
- reproduce the systemic legitimacy of impersonal norms and principles;

[1] Legal systems as emergent phenomena were presented in my most recent three books – Status prawny i dynamika porządku prawnego, Łódź 2017; Teoria i filozofia prawa: wykłady, Gdynia 2019; Interpretacja prawnicza: omnia sunt interpretanda, Warszawa 2020.

- not violate cultural identities and traditions that are alive in the social memory of large groups of the people and expressed in morality or the rules practical prudence and common sense;
- be conducive to social and economic development and to expectations about the quality of living in a specific time.

I assume that there can be at least two sets of criteria that could allow us to make a reasonable valuation of regulative efficiency of legal systems defined by the following questions:

- how many subjects under the given legal system obey the rules and principles of this system of regulation? How many of them do what they should do?
- and if they do not obey the law, are they duly punished by any established public authority?

My purpose in this essay is to claim that international law at present is less efficient than many of the domestic legal systems due to the following reasons: a. the very nature of sources of international law, b. impossibility of full cultural adequacy of international law because there are too many and too different cultures on the Globe, and c. the strategic power game of superpowers that leads to frequent acts of strong states which disregard international law without being punished for this. The present essay will focus only on the first reason for the weakness of international law in providing solutions. Let us look at a realist critique of the sources of international public law.

2. SOURCES OF INTERNATIONAL PUBLIC LAW AS AN OBSTACLE TO ITS EFFICIENCY

There is a great variety of sources where one can find rules regulating actions of participants in the international system or world order, such as multilateral and bilateral treaties, international customs, general widely recognised principles of law, decisions of national and lower courts and scholarly writings of legal experts of high professional reputation. Article 38(1) of the Statute of the International Court of Justice is generally recognized as a definitive statement of the sources of international law. It requires the Court to apply, among other things, (a) international conventions, whether general or particular, establishing rules expressly recognized by the contesting states; (b) international custom, as evidence of a general practice accepted as law; (c) the general principles of law recognised by civilized nations; (d) subject to the provisions of Article 59, judicial decisions and the teachings of the most highly qualified of the legal experts of various nations, as subsidiary means for the determination of rules of law.

The sources of international public law are to a lesser degree a system than the sources of domestic law because their hierarchy is less consistent and is

a subject of ongoing debate in the expert's community[2]. The hierarchy of norms and their sources increases the regulative efficiency of legal systems and contributes to a deeper and clearer interpretation of legal norms and facts of the case under scrutiny. The missing link in this chain of interpretative decisions is a shaky and disputable hierarchy of norms in international law. The second missing component is the lack of interconnections between different types of sources of international law.

2.1. TREATIES AND THE *IUS COGENS*

The hardest pieces of international law are multilateral conventions and bilateral treaties which are sometimes regarded as a positive law or at least as an equivalent of positive law enacted in municipal systems nowadays. The preference between sources of international law is given to treaties so the rules established by treaty should take preference if such a valid and relevant treaty exists. But in many cases it does not exist or there are obvious inconsistencies between the multilateral convention and a bilateral treaty that could apply to the facts of the case. If there are two treaties valid and binding, i.e. multilateral and bilateral, it is not clear which one shall take preference. Such a gridlock is extremely rare under domestic law. This kind of missing hierarchy is exacerbated by the fact that international law has no equivalent to a constitutional act of the supreme authority. There is, however, one convention that can be perceived as superior to any other treaty – the obligations under the United Nations Charter override the terms of other treaties (Article 103 of the United Nations Charter).

Above the UN Charter there is something incurably unclear but highly regarded as a supreme set of rules. A peremptory norm, or *ius cogens,* is a principle of international law considered so fundamental that it overrides all other sources of international law, including even the Charter of the United Nations. The principle of *ius cogens* is enshrined in Article 53 of the Vienna Convention on the Law of Treaties: "For the present Convention, a peremptory norm of general international law is a norm accepted and recognised by the international community of States as a whole as a norm from which no derogation is permitted and which can be modified only by a subsequent norm of general international law having the same character". The trouble is that this regulation presupposes that there exists such a community of States as a whole" or at least that this variety of community is feasible in a foreseeable future. It is doubtful and this presupposition seems to be an effect of the wishful thinking very remote from the real world in which we must live.

The list of *juris cogentis*' rules is not very long, as it includes prohibitions of such crimes and wrongful acts as waging aggressive war, war crimes, crimes

[2] M. Prost, *Hierarchy and the sources of international law: a critique*, (in:) The Oxford handbook on the sources of international law, Jean d'Aspremont Samantha Besson eds., 2017.

against humanity, piracy, genocide, apartheid, slavery and torture. Respect for fundamental human rights and first of all human dignity and freedom is regarded as *ius cogens* but there is no overall agreement about this matter among legal experts[3].

Another trouble with *ius cogens* is that it remains unclear who may decide about the extension of the catalogue of norms that belong to this supreme category. What we know is that the emergence of a rule of *ius cogens* should be essentially similar to that required to establish the creation of a new rule of customary international law. Therefore, *ius cogens* could be perceived as a special principle of custom with superadded opinions strongly influenced by particular interest of policymakers among the ruling groups in more than 200 states.

The structural shortcoming of the treaties is their limited binding force in comparison to enacted bills or other acts of domestic law. Domestic laws are equally binding for all physical and legal persons who are present on the territory of a given state. Treaties are binding sources of obligations for the parties to them. Contractual obligation cannot be imposed on a state by international treaty without the consent of the subject to it expressed in an act of ratification. Domestic laws impose legal obligations upon its subjects without their consent; this unpleasant truth is taken seriously as a trivial necessity even in liberal democratic states with long and decent traditions of responsive governance. It is more true in totalitarian and authoritarian regimes, that are unfortunately more widespread than democracies. In international law, only the rules of the *ius cogens* have a universal character and apply to all states, irrespective of their wishes and interests.

2.2. CUSTOMARY LAW

International customs are binding for all members of the global system but there are only very few multilateral conventions of universal, general applicability all over the Globe. For example, laws on global commons or laws regulating the *ius ad bellum* are universally approved and applicable. Most of the conventions are limited in the scope of their possible application and their effectiveness depends upon the number of states that ratified or acceded to the particular convention. Only a few such conventions have a sufficient number of parties to be regarded as international law in their own right. A universal or near-universal degree of formal acceptance is a rare situation. The Geneva Conventions for the Protection of War Victims of 1949 and the Vienna Convention on the Law of Treaties 1969 are rather exceptions to the rule than a rule itself in this regard.

Many treaties are interpreted as if they were customary law, because some actors have a vested interest in extending their binding power upon non-parties.

[3] V. D. Degan, Sources of international law, Netherlands: Martinus Nijhoff Publishers, 1997.

Legal security and certainty of law are at risk in such situations and the general efficiency of treaties decreases.

Another practical trouble with a treaty is that as a part of its formal parties there may be some states that accepted the obligations of a treaty to which they are not party (never signed it duly, or signed, but never ratified). Limits to the validity of the treaty are more complex than the above-mentioned uncertainty. The treaty can be regarded as a source of law only when it is capable of affecting non-parties or has consequences for parties more extensive than those specifically required by the treaty itself. Thus, it is never certain if the specific treaty is a *ius cogens* (peremptory law) or not. Therefore, legal rule based on the treaty is to a greater extent created by the interpretation and application than it is in the case in an application of domestic law. It may have an impact on a lower efficiency of international law.

It is far from certain whether international treaties and international customs are sources of international law of equal validity. If we regard them as equally valid, it should mean that new customs may supersede older treaties and new treaties may override older customs. Also, *ius cogens* (peremptory norm) is rather a custom, not a treaty. Customary laws are replaced by enacted laws in domestic legal systems, but in international law many old customs survive for a longer time and make a clear hierarchy of sources almost impossible. Many customs cause a lot of confusion due to the lack of precise wording.

Article 38(1)(b) of the ICJ Statute refers to "international custom" as a source of international law emphasizing the two requirements of state practice plus acceptance of the practice as obligatory or *opinio juris sive necessitatis*. Both requirements are quite confusing and increase the risk of misinterpretation. Shall we regard as the state practice only real deeds of governments, or some words of its diplomats or leaders at the United Nations General Assembly as well? Are words only an expression of *opinio iuris* or are they a specific form of practice? And, if some speeches we can perceive as actions in practice, who should decide what speeches and how performed or by whom are of such weight that we can evaluate them as if they were practical deeds? How common, long-lasting, and consistent some practices must be to be rightly understood as *usus longaevus* that makes a customary law?

For more than 70 years it remains unclear whether official practices of the UN Security Council or The General Assembly may be regarded as an agreeable premise for the emergence of customary law. Debate on consistent practice and opinio iuris have led to one quite reasonable conclusion that both premises are equally important in the emergence of customary law. But this nice certainty is unfortunately not very good news. *Opinio iuris* is of course referring to individual psychology and a reasonable person can ask: what would be less certain than acts of an individual psyche about the validity of some institutional practices?

2.3.GENERAL PRINCIPLES OF LAW

Even more confusion is made by „the general principles of law recognized by civilized nations" recommended as a source of international law by Article 38, paragraph 1(c) of the Statute of the International Court of Justice. Such standards are justified as rational derivations from many domestic legal systems: the standard of restitution for harm committed, the standard of rule understanding, modes of reasoning used for rule struggles, such as "*lex posterior derogat legi priori*", "*lex superior derogat legi inferiori*", and many other, such as: "*audiatur et altera part*", "*actori incumbit onus probandi*", "*pacta sunt servanda*", the principle of good faith, the principle of equity or estoppel. It is notoriously unclear whether general principles of law (sometimes simply principles of jurisprudence) should be recognised as principal or auxiliary sources of international law.

The scope of general principles of law is unclear and controversial. Despite this ongoing controversy, there is a widespread perception of general principles as an interpretative directive to the International Court of Justice to fill any gap in the law by reference to the general principles. There is a certain paradoxical logic in it – the more principles are unclear, the better they will serve the judges in their efforts to fill all gaps in treaties and customs. Even many hard-line legal positivists supported the application of general principles of law, provided that they had in some way been accepted by states as part of the legal system.

2.4. JUDICIAL DECISIONS AND SCHOLARLY WRITINGS

What is certain and agreed upon by modern jurisprudence, is that judicial decisions can be regarded as auxiliary sources of international law. Judicial decisions are nothing more than an auxiliary source of international law because there is no rule of *stare decisis* in international public law. The decision of the International Court of Justice in the Hague has no binding force except between the parties and in respect of a particular case. Nobody has a duty of following the pattern of a decision in a specific ruling of the court.

The scholarly works of prominent jurists are not regarded as sources of international law. However, the wisdom of the best legal scholars helps develop the rules that are rooted in treaties, customs, and the general principles of law. This is accepted practice in the interpretation of international law.

2.5. SOFT LAW

Another trouble-making source of international law is the soft law, which is based on the agreement between the states. It seems to be a variety of a strong recommendations, similar to *ius dispositivum* in municipal law; it is not binding but is valid, it is not a compelling reason for obedience and does not impose obligations, but rather a mutual promise that agreed action will be undertaken in

a good faith. It is normativity, but less than commitment. Its legal force is undefined but real, this force is more than a mere possibility. Soft law is legally significant and relevant, but is unable to impose binding obligations on participants to the process of its emergence.

Soft law is not created as treaties, but rather is an emanation or emergence than the final product of the political will. Soft law „emerges", confirming the theory of emergent legal systems and legal orders. The subjects of international law in the third decade of the XXI century are not just states as it was in 1945, as many new highly motivated and powerful actors have emerged, such as international organisations, worldwide NGO's and multinationals. What is an even more relevant argument against the formalistic tradition of sources of international law, is a well-known fact that the practice of hundreds of new subjects is constantly changing realities and thus makes fertile ground for the spontaneous surfacing of the soft law.

3. CONCLUSIONS AND RECOMMENDATIONS

A semi-chaotic and non-systemic picture of the set of sources of international law may seem to be pessimist and perhaps somewhat exaggerated. It is made, however, with an intention that we, the lawyers, should do much more for better ordering these sources and therefore increase the systemic efficiency of international law. Global problems of humankind are serious enough and they cannot be solved just by the power games of politicians, competition among big corporations, and innovative ideas of technology designers.

International law must adapt faster to challenges and genuine global threats to preserve its regulative efficiency and innovation capacity in the future. The dignity of international law depends on broadening the traditional list of its sources. There is urgent need to prepare multilateral conventions on global epidemic diseases, natural disasters and the military use of drones. Better organised and more efficient international law may become a tool in humanistic social engineering on a global scale. I do not accept the approval of the present disorder in the sources of international law advocated by Jean d'Aspremont, despite the fact that I have learnt a lot from his works.

More efforts should be devoted to the ideas and projects of the constitution for the human community on the Globe which should clearly define what is *ius cogens* (human rights of all generations, many segments of space law for example), and what is soft law and how to apply it to the spontaneous or even chaotic dynamism of facts[4]. Real facts must compete with fake facts. Legal norms may help to make a proper distinction between the real, the virtual, and the

[4] T. Widłak, From international society to the international community. The constitutional evolution of international law, Gdansk 2015.

fake. Global law may help our efforts in improving the quality of human knowledge.

The new concepts of the sovereign state, such as shared sovereignty or limited sovereignty, should be regarded seriously while interpreting and implementing all sources of international law and all relevant facts of the cases. Rules and institutions are instrumental to the practical application of fundamental values, such as peace, security, justice, and freedom. Rule of law in the global system exists only in rudimentary forms. International law must get stronger to make the rule of law a public global good.

The dignity of human beings demands stronger, more efficient and better legitimised international law. Scholars and politicians must build together a new tradition of the discourse on global problems. The theory of formalism in legal science should be re-evaluated against the backdrop of the growing acceptance by international legal theorists of the blurring of the lines between law and non-law, by opening the law to the rules of morality, practical prudence and common sense.

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THINKING OUT OF THE BOX: THE HUMAN BEING IN THE AI ERA

Abstract: We are witnessing increasingly widespread and already indispensable technology inhabit our homes, businesses, schools, public offices, streets, but also bodies and minds. Applications range from natural language processing, through logical AI inferencing, artificial neural networks, to machine perception and motion manipulation widely used in many industries, but also to the prospective birth of the synergic mind based on human-computer interactions. With time and growing excellence and complication of algorithms, more difficult questions arise: not only technical, but also legal, ethical, social, political and economic. Key legal issues relating to the use, acquisition, and development of AI cover a wide array of fields: commercial contracts and tort law, consumer protection and products liability, privacy, data security and other fundamental rights, intellectual property, labour law or antitrust. These questions are interrelated with ethical problems, including whether the strong – as opposed to currently employed narrow artificial specialized intelligence or ASI, with defined goals and no self-awareness – the artificial general intelligence (AGI) may at some point pose an existential threat pursuing goals that – in the extreme – are not even aligned with preservation of mankind. Not less important are closely linked social, economic and political issues, rooted in fear of unequal distribution of profits from this unprecedented exponential tech revolution. The authors make a humble attempt at addressing these problems in a comparative and interdisciplinary perspective.

Keywords: Artificial Intelligence, AI & the law, EU AI White Paper, US approach to AI, privacy and data protection, opportunities & threats for humanity, AI in courts, AI in public administration, AI & judicial dialogue

INTRODUCTION – CREATING AND HARNESSING THE WORLD OF ROBOTS

The Future Life Institute – authoring one of the circulating sets of principles on AI development, supported by practitioners and academics alike[1] – is one of the think tanks which considerably contributed to placing artificial intelligence problems at the centre of interdisciplinary research. An avid supporter of AI expansion, Max Tegmark, offers a classification of life as divided into three phases: Life 1.0 – biological phase, Life 2.0 – cultural phase and, finally, Life 3.0 – technological stadium, with AI at its centre[2]. As Steven Pinker pointed out in a podcast available on FLI website: „It's one of the great achievements of neuroscience, on the one hand, to show that a brain is capable of supporting problem solving, perception and decision making, and of the computational sciences, on the other, for showing that intelligence can be understood in terms of information and computation, and that goals (like the Aristotelian final cause) can be understood in terms of control and cybernetics and feedback"[3].

In the world of robots, it is utterly important that they are able to handle complex tasks while efficiently interacting and collaborating with multiple agents: humans and other robots[4]. Computers clad in a more or less human-like outer shell are expected to mock humans: sense, learn, reason, and take action. It is, therefore, necessary that accurate models are developed capable of producing predictable output based on received data[5]. Humans „routinely make such inferences in their social interactions using the theory of mind: reasoning about others as agents with their own mental states – such as perspectives, beliefs, and intentions – to explain and predict their behavior. Alternatively, one can think of the theory of mind as the human ability to imagine the world from another person's point of view"[6]. Humans came to realize the importance of

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1 Among others: Ray Kurzweil, Nick Bostrom, Andrew Ng, Erik Brynjolfsson, Max Tegmark, Elon Musk and Larry Page.

2 M. Tegmark, Życie 3.0. Człowiek w erze sztucznej inteligencji (Life 3.0. Human Being in the Age of Artificial Intelligence), Prószyński i ska, Warszawa 2019, p. 46.

3 S. Pinker, https://futureoflife.org/2020/06/15/steven-pinker-and-stuart-russell-on-the-foundations-benefits-and-possible-existential-risk-of-ai/ Accessed on 5 Dec. 2020.

4 In the near future human interactions with intelligent machines will become daily routine, ranging from customer service to medical care. There are hardly any limits in the attention and kindness that accordingly programmed bots can expend on another person, channeling unlimited resources into building relationships.

5 A. Hayashi, D. Ruiken, T. Hasegawa, Ch. Goerick, Reasoning about uncertain parameters and agent behaviors through encoded experiences and belief planning [in:] Artificial Intelligence, Volume 280/2020, https://doi.org/10.1016/j.artint.2019.103228. Accessed on 5 Jan. 2021.

6 N. Bard, J. N. Foerster, S. Chandar, N. Burch, M. Lanctot, H. F. Song, E. Parisotto, V. Dumoulin, S. Moitra, E. Hughes, I. Dunning, S. Mourad, H. Larochelle, M. G. Bellemare, M. Bowling, The Hanabi challenge: A new frontier for AI research [in:] Artificial Intelligence, Volume 280/2020, https://doi.org/10.1016/j.artint.2019.103216. Accessed on 5 Jan. 2021.

addressing this question as soon as the 60s, when primary attempts at creating artificial intelligence proved likely to be successful. Ever since, „there have been advances in search algorithms, machine learning algorithms, and integrating statistical analysis into understanding the world at large"[7]. We are now witnessing increasingly widespread and already indispensable technology inhabit our homes, businesses, schools, public offices, streets, but also bodies and minds. Applications range from natural language processing, through logical AI inferencing, artificial neural networks, to machine perception and motion manipulation widely used in many industries, but also to the prospective birth of the synergic mind based on human-computer interactions (HCI)[8]. Fostering digital economy correlates with the vast number of cloud computing resources and consumer demand for on-line services. With time and growing excellence and complication of algorithms, more difficult questions arise: not only technical, but also legal, ethical, social, political and economic[9]. Key legal issues relating to the use, acquisition, and development of AI cover a wide array of fields: commercial contracts and tort law, consumer protection and products liability, privacy, data security and other fundamental rights, intellectual property, labour law or antitrust. These questions are interrelated with ethical problems including whether the strong – as opposed to currently employed narrow artificial specialized intelligence or ASI, with defined goals and no self-awareness – the artificial general intelligence (AGI) may at some point pose an existential threat pursuing goals that – in the extreme – are not even aligned with preservation of mankind[10]. Not less important are closely linked social, economic and political issues, rooted in fear of unequal distribution of profits from this unprecedented exponential tech revolution[11], possibly resulting in massive unemployment not just in the developing countries but threatening virtually any profession other than the ICT sector. This, in turn, may give rise to even more violent outbreak of resentment on the part of those who suffer from social exclusion than we have so far witnessed, and, thus, render the ever-growing neglected class even more sensitive to populist propaganda – spread through still under-regulated social media transpired by murky algo-

[7] Ch. Smith et al., The History of Artificial Intelligence, History of Computing CSEP 590A, University of Washington, December 2006.

[8] Cf. D. F. Noble, Religia techniki. Boskość człowieka i duch wynalazczości (The Religion of Technology. The Dignity of Men and the Spirit of Invention), tł. K. Kornas, Copernicus Center Press, Kraków 2017, p. 277.

[9] M. Stankovic et al, Exploring Legal, Ethical and Policy Implications of Artificial Intelligence; Law, Justice and Development, September 2017 https://www.researchgate.net/publication/320826467 accessed on 6 Jan. 2021.

[10] Assessing the risks of Artificial Intelligence, WEF, at http://reports.weforum.org/global-risks-2017/part-3-emerging- technologies/3-2-assessing-the-risk-of-artificial-intelligence/#view/fn-6 6, accessed on 10 December 2020.

[11] D. Rotman, Who will own the robots, MIT Technology Review (June 2015), at https://www.technologyreview.com/s/538401/who-will-own-the-robots, accessed on 10 December 2020.

rithms. The address of Ursula von der Leyen at the 2020 WEF summit in Davos, if not much belated, is worthy of praise and extensive quotation:

> *„A year ago at Davos, we talked also intensively about digitalization. The pandemic has massively accelerated the process. The European Union will dedicate 20% of NextGenerationEU to digital projects. To nurture innovative ecosystems, for example where universities, companies, innovators can access data and cooperate. (…) So that the 2020s can finally be Europe's Digital Decade. But for this to be a success, we must also address the darker sides of the digital world. Like for so many of us, the storming of the Capitol came as a shock to me. We are always quick to say: Democracy and values, they are part of our DNA. And that is true. But we must nurture our democracy every day, and defend our institutions against the corrosive power of hate speech, of disinformation, fake news and incitement to violence. (…) The business model of online platforms has an impact – and not only on free and fair competition, but also on our democracies, our security and on the quality of our information. That is why we need to contain this immense power of the big digital companies. Because we want the values we cherish in the offline world also to be respected online. At its most basic, this means that what is illegal offline should be illegal online too. And we want the platforms to be transparent about how their algorithms work. Because we cannot accept that decisions, that have a far-reaching impact on our democracy, are taken by computer programs alone. We want it clearly laid down that internet companies take responsibility for the manner in which they disseminate, promote and remove content. (…) There needs to be a framework of laws for such far-reaching decisions. This is why the Commission launched the Digital Services Act and the Digital Markets Act in December. This is our new rulebook for our digital market"*[12].

More recently, the focus of both research and development is on the following applications: large-scale machine learning, artificial neural networks (ANNs), Natural Language Processing (NLP) analysing human speech based on deep learning, collaborative systems, algorithmic game theory and computational social choice drawing attention to the economic and social computing dimensions of AI, reinforcement learning based on experience-driven sequential decision-making. All the above may aid, though not always serving transparent incentives, many fields of industry and everyday life: medical diagnosis, farming, wild-life preservation, entertainment, individual and public safety and security, the Internet of Things (IoT), writing sports reports, trading stocks, multi-purpose smart phone applications, autonomous vehicles, to name but a few. Bank of America

[12] Special Address by President von der Leyen at the Davos Agenda Week, 26 Jan. 2021, https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_21_221, accessed on 25 Jan. 2021.

Merrill Lynch estimates probably rightly point at ca. 2 trillion U.S. dollars in AI-generated global cost-efficiency – a figure that is not to be underestimated and that creates market incentives calling for regulators to exercise ultimate caution, monitoring and surveillance based on clear guidelines[13].

APPLICATIONS TO LEGAL SERVICES: AI AIDING THE PUBLIC ADMINISTRATION

Automated decision-making systems (ADS) include algorithms assisting human decision-making, ie. any computer technology that either assists or replaces human decision making. ADS does not cover AI sensu stricto, but those more conventional systems also pose risks. According to EU Commission initiatives further developed by think-tanks such as the European Law Institute[14] there is a need for "evaluation by internal and external auditors, and the availability of such evaluation reports can contribute to the trustworthiness of the technology"[15]. Such an independent assessment „will increase trust and ensure objectivity"[16], its subject being the evaluation of the impact assessment report done by Expert Boards who are required to possess knowledge of AI systems, knowledge of the public authority's tasks and responsibilities, be impartial and represent diverse social, gender, racial and national groups with different professional backgrounds. The outcomes of their work – reports and recommendations –

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13 M. Stankovic, supra, p. 9.

14 Cf. ELI „Project on Artificial Intelligence (AI) and Public Administration – Developing Impact Assessments and Public Participation for Digital Democracy", which follows on from a preceding feasibility study on the matter, announced on 1 May 2020. Not less important in the dawn of unprecedented growth of big data use is another European Law Institute project: „Principles for a Data Economy", executed in collaboration with the American Law Institute. For more up-to-date information consult: www.europeanlawinstitute.eu.

15 The independent High Level Expert Group on AI, set up by the European Commission to address key AI issues within the framework of the EU, drafted four deliverables, including: Ethics Guidelines for Trustworthy AI which „puts forward a human-centric approach on AI and list 7 key requirements that AI systems should meet in order to be trustworthy"; „ Policy and Investment Recommendations for Trustworthy AI" – a list of „33 recommendations to guide trustworthy AI towards sustainability, growth, competitiveness, and inclusion"; „The final Assessment List for Trustworthy AI (ALTAI)", translating „the Ethics Guidelines into an accessible and dynamic self-assessment checklist for developers and deployers of AI" and, finally, „Sectoral Considerations on the Policy and Investment Recommendations" referring to three spheres: the Public Sector, Healthcare and Manufacturing the Internet of Things. https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai Accessed on 20 October 2021, See also: Ethics Guidelines for Trustworthy AI. See also: Towards a Code of Ethics in Artificial Intelligence with Paula Boddington, Davey, Future of Life Instituute, at https://futureoflife.org/2017/07/31/towards-a-code-of-ethics-in-artificial-intelligence/ Accessed on 20 October 2021.

16 European Commission White Paper on Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020 COM(2020) 65 final.

should guarantee audit integrity and procedural justice[17]. Therefore, some algorithms would be subject to assessment, some not (ie. spell-checkers), while still other will be screened for potential risks. In this context, Art. 35 GDPR provides a good model with a data controller and data protection authority at the core of safeguarding protected interests. However, as regards AI, the legal framework needs to be clearer than mere ethical guidelines.

Lawyers tend to be conservative, but those who work in the public administration as well as – increasingly, especially in the pandemic era – those who form law enforcement and the judiciary, try to make their work more efficient with the use of AI. Technically speaking, most of the systems used in this setting are not AI, but rather they use technology to enhance the work of public authorities. Nevertheless, lawmakers adhere to the old approach, trying to safeguard original humanitarian legal values at the outset. Relevant documents drafted so far globally, not many of them binding as yet, deal with human rights and ethical approach, because legislators are historically accustomed to analysing these issue. It is doubtful whether we can translate old traditional problems into the digital language; in other words, at the outset a question must be answered: is there an inherent breach between information technologies and human rights? With respect to data protection, competition and consumer protection, competent authorities oversee and supervise their functioning permanently; also in the field of AI impact assessments are welcome. While it is desirable to speed decision making, it is also crucial to protect people against wrong automated decisions. The „red button" dilemma concentrates on the question: whether and how we can take out a single unjustly decided case from the automated system.

Given the above, nationally adapted and iterative evaluations may be needed, but at the same time risk for regulatory overload will potentially drown any AI project and hinder the Internal Market. At the moment, there are several different platforms of sharing information, ie. Internal Market, competition networks, tax authorities, public procurement, but even more elaborate platforms will ensue, therefore it is ever more important to ensure transparency, yet at the same time to meet often conflicting data protection requirements. Another issue raising doubts are the standards of assessment with the central question: how to secure the principles of good administration (duty of care, right to be heard, reasoned decisions) and transparency in the decision-making process[18]. Not less important is addressing the problem: "who will guard the guardians" by defining the principles regulating the supervision of input, but also, perhaps even more importantly, the clandestine processes taking place in the AI „black box"[19]. There might

[17] Eg. predictive policing can pose risks of discrimination as the police relying on AI tend to discriminate the inhabitants of certain areas, which will lead to ethnic profiling.

[18] Cf. M. Ananny, K. Crawford, „Seeing without Knowing: Limitations of the Transparency Ideal and Its Application to Algorithmic Accountability"20(3) 2018 New Media Society, p. 973.

[19] One infamous example is COMPAS, the Northpoint Inc. algorithm used by US courts to predict reoffending criminals. The algorithm weighed 100 factors such as: prior arrests, family

appear the need in the case of self-learning AI to envisage iterative assessments and perhaps introduce ex-post evaluation, which weakens the efficiency and the sense of employing algorithms in the first place. One possible solution is on-going monitoring, another would be scheduled re-evaluation or a system for revocable permits. Furthermore, any requirements elaborated at the European level may need to be adapted to national rules. Yet another problem to be solved is: how to secure the EU Internal Market and uphold national administrative requirements or balance the regulatory overload with respect for national administrative law traditions, while nationally adapted and repetitive evaluations cannot be avoided. It is important to have a system that rises above national traditions, which could be attained with a set of simple, general, not excessively detailed regulation, that would set standards for all Member States.

There is virtually no way to avoid bureaucracy, especially with respect to a system that works in several jurisdictions. Supervisory bodies do not have to be EU or public bodies, however; there is plenty of room for self-regulation which is both proportionate and in line with the principle of subsidiarity, but on the other hand leads to doubts on how valuable a system is and how much it would need to rely on the vigilance of the individual concerned, who would then have to complain using the traditional system for redress[20]. Whatever the final solution, traditional law cannot control AI, but AI should neither be relied upon to supervise AI[21], and any human-designed standards should be based on good administration.

Reference should be made to ethics documents, such as one of earliest attempts drafted in Canada[22], which promises clear-cut answers based on an interactive form to be filled out on-line by a human supervisor – AI developer or user, but creating a danger that a person downplays the risk of the system. In addition, the survey is also designed in a very formalistic manner, by which it may not take

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life, drug use, age and sex, and predicted the likelihood that a defendant would commit another crime. Despite the lack of intentional inherent racist bias, the algorithm incorrectly labeled black defendants as "high risks" almost twice as often as the white defendants. M. Miron, S. Tolan, E. Gómez, C. Castillo, Evaluating causes of algorithmic bias in juvenile criminal recidivism, Artificial Intelligence and Law 29/2021, p. 125. Cf. Northpoint, Inc. (2012) Compas risk and need assessment system. Northpoint, Inc, Tech. rep.

20 M. E. Kaminski, G. Malgieri, Algorithmic impact assessments under the GDPR: producing multi-layered explanations, International Data Privacy Law, 2021, Vol. 11, No. 2, p. 128. See also: K. Crawford, J. Schultz, 'Big Data and Due Process: Toward a Framework to Redress Predictive Privacy Harms' 55(1) 2014 Boston College Law Review, p. 93.

21 Research is needed concerning mechanisms that provide in addition to privacy by design also "accountability by design". See: J. – P. Schneider, Response to the public consultation on the White Paper: On Artificial Intelligence – A European approach to excellence and trust, COM (2020) 65 final, European Law Institute, p. 4-5.

22 S. Hodgett, T. Liu, A. Perey, AI, Machine Learning Big Data Laws 2021. Canada, https://www.globallegalinsights.com/practice-areas/ai-machine-learning-and-big-data-laws-and-regulations/canada Accessed 15 August 2021.

into account individual cases and subtleties. Impact assessment systems for AI are developed by analogy to environment impact assessments – they take a holistic approach and integrate useful and helpful criteria. Any solutions should be communicated to the public in an easy and effective, accessible language, access to information, being a civic right under the the ECHR and CFR[23], and subject to public consultation, as it is crucial to build the trust and make it easier for people to understand how AI and its supervision on the UE level actually works.

APPLICATIONS TO LEGAL SERVICES: AI IN COURTS

Programming language, or "code", which is more elaborate than any human language, allows the machine to be instructed at every stage of its reasoning with precision as to what task must be performed, since it cannot invoke common sense in the absence of an explicit directive of behavior[24]. The code must be devoid of any error in order to allow for smooth, unflawed functioning of the algorithm which decides on issues ranging from financial institutions' investment and lending decisions through enhancing court efficiency and expedient proceedings to assessing the risk of recidivism in criminal cases and adjusting the sentence accordingly[25].

Efficiency is the measure applied to evaluate services rendered both within the scope of market economy and the society, in the public and private sphere. Judicial justice and ADR should be assessed yet from another perspective – that of fairness. Justice delayed is justice denied[26], therefore expediency serves both purposes and application of algorithms may significantly improve dealing with workload by appropriate case assignment and, consequently, reducing the length of proceedings, which is particularly important for doing business. On the other hand, parties may want to accept a more extended and thorough examination of evidence with view to elevating the quality of the decision – one must not forget that people are looking for being heard and understood, which belongs to the wider principle of the right to court as enshrined in Article 6 ECHR and 47 CFR[27]. Independence and impartiality, ascertained by the constitutional principle of separation of powers, but also through education, training and selection process as well as judicial immunity and scope of disciplinary responsibility, are indisputable elements in court as well as – to an extent – in the out-of-court dispute resolution systems. Justice can only be evaluated in a weighted manner,

[23] Under Article 10 ECHR, Article 11 and – with respect to EU documents – Article 42 CFR.
[24] A. van den Branden, Les robots à l'assaut de la justice, L'intelligence artificielle au service des justiciables, Bruylant, Bruxelles 2019, p. 6.
[25] Ibidem, pp. 6 et seq.
[26] W. E. Gladstone.
[27] A. van den Branden, op. cit., p. 20.

using a coefficient measuring importance attributed to selected criteria, such as quality, cost and expediency of proceedings[28], presented to a group of evaluators who award a given number of points from a given pull, equal for all of them and summing up to the same number, eg. 100[29]. The creation of an appropriate matrix and selection of criteria to be assessed is of crucial importance, the Council of Europe „Measuring the quality of justice" being critiqued for operating with questions of very little importance while neglecting the actual content and merits of court decisions[30]. Any analytical debate using arguments for and against robotization of justice must focus on opportunities offered by but also threats inherent in the increased use of machines enhancing or even – with time – substituting human performance[31].

AI, DEMOCRACY, NORMATIVE DISCOURSE AND JUDICIAL DIALOGUE[32]

Information technologies are being perfected and are getting cheaper; as a result, there are no economic barriers to developing judges' dialogue. Therefore, not only the gap in national law or the need to get acquainted with the interpretation of foreign law by the local courts in cross-border disputes, but also the imperative of efficiency implies using the experience of partners from other countries. This phenomenon is known as judicial comity, which is based on respect for the law and its interpretation by courts in another jurisdiction. The long-term effect of the judicial dialogue intensifying and spreading globally is the strengthening of ties between legal systems that interact and even the

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28 This methodology. requires the factors representing weight given to each criterion to sum up to the same number – eg. 100 – for all evaluators.

29 A. van den Branden, op. cit., p. 21.

30 cf. European Commission for the Efficiency of Justice, „Measuring the quality of justice", as adopted on 7 December 2016, at the 28th plenary meeting of the CEPEJ. The document refers to 2 yardsticks: conformity with requirements (assuming pre-defined quality parameters and fixed standards of quality) and conformity with expectations. Authors do concede that „ it would not make sense, given the different legal systems and the many specific features of each judicial system, to formulate a trans-national methodology. Moreover, the concept is so large that it cannot be reduced to a unique technique or methodology." At the same time, a checklist is created, containing seven identified essential elements of the intrinsic quality of the jurisdiction.

31 For example, a model of evaluation of justice proposed by van den Branden – both a practicing lawyer and IT specialist – offers three possible results for each criterion of assessment: either the algorithm prevails substantially over human reasoning, or the other way around, or man and machine are performing equally well. Cf. A. van den Branden, op. cit., p. 21 et seq.

32 Ideas here presented are further developed alongside relevant case law in a forthcoming book by M. Konopacka on global judicial dialogue inferring from and impacting modern legal cultures.

mutual penetration of elements of legal cultures. Short-term cross-border discourse creates a virtual training ground, allowing you to test different solutions, transplant them into your own land. Certainly, conversation through citations, even if it is not symmetrical, enables decisions based on wider knowledge and more data, more complete information than in the case of silence and isolation. Another aspect, which becomes more important after making a decision about seeking helpful judgments and deciding about the choice of specific judgments of specific courts, is the frequency with which these judgments have been used by the courts so far. We like the songs that we already know and are happy to follow proven patterns. Judges are also people, so they make a similar selection, based on the suggestions of other judges or knowing about the popularity of a particular judgment, sometimes due to the popularity of the author – a judge with a distinct personality. Supported by information technologies (search engines, databases on the websites of individual courts, legal information systems) that further increase randomness and make the result dependent on the exact sequence of words entered, the judges actually have innumerable sources of inspiration. However, this does not apply to time, human resources or even language skills. The constructive and proper use of jurisprudence outside its own jurisdiction (even when it comes to ECJ or ECtHR judgments) depends on all of the above factors.

It often happens that state communities desire and seek non-national justification for the solutions adopted to tackle novel problems. This is particularly true in transient situations: at the time of political, economic, social and, of course, legal transformation, of countries once enslaved by a foreign regime or internal dictatorship (e.g. Central and Eastern European countries, Latin America, South Africa), but also in the dusk of unprecedented technological leap which the present generations will unavoidably witness in their lifetimes. The policy of internationalism and nationalism is another element that is variable in the world of judicial dialogue. Some states go as far in their constitutions as to require judges to indicate external sources of justification for their decisions, while countries with established democracy often discourage this. Finally, judges themselves are more or less friendly and open to foreign inspiration when passing judgments. Judges, as has already been pointed out by Foucault, must also convince themselves or, as Posner – himself a federal judge frankly concedes[33] – they must convince their colleagues from the bench, but potentially also lower or higher court judges. Equally, they should have their auditorium in mind, that is, first and foremost, the parties to the dispute, but it is difficult to imagine a court decision that is not persuasive towards a wider audience – the local community, the entire

[33] R. Posner, Nine Theories of Judicial Behaviour [in:] How Judges Think, Harvard University Press 2008, pp. 19-56. Cf. M. Konopacka, "Wielopoziomowa niesprawiedliwość" a "Sędzia" albo "Złota Legenda o Świętym Jerzym" opowiedziana we współczesnej Europie", Centrum Europejskie Natolin 2010, pp.40-43.

nation, and even citizens of larger communities: the Commonwealth, the European Union or even the whole world (as applicable).

Judges also speak to the other authorities, especially to the executive. The analysis of legal discourse proposed by Michel Foucault is not easy to read, but literally perfect and philosophically captivating. Rejecting the accusations of deeply Marxist or nihilist Nietzschean inspirations – by borrowing only the concentration of philosophical discourse on economy and power, respectively – Foucault proposed his own concept of the relationship between law and power, becoming a pioneer of the commonly proclaimed juridisation of everyday life or the colonization of society by law[34]. Based on historical, economic and social analysis, but also on language studies, Foucault approached the interdisciplinary concept of legal discourse[35]. He studied the mutual relations of law, morality and knowledge as well as the use of forms, language and institutions to exercise power at every social level. His works undermine the modernist visions of the individual's central position, legal formalism, progress and the idea that emancipation is always possible through the growth and application of scientific knowledge. [Foucault] studies contribute to the establishment of critical knowledge that opposes domination, especially in its rational, legally administered forms, where appropriation of power is justified by the possession of knowledge. (...) His research shows how the correlations between legal discourses, various forms of knowledge, political economy, governmental techniques and institutions of social control create the logic of power that can be grasped most fully by analyzing its detailed applications (especially at times of transformation and technological change).

Foucault's perceptiveness and skepticism, perhaps even visionaryism, should be appreciated regardless of the assessment of his biography, which significantly influenced the increased criticism, and even reluctance to the oppressive function of degenerating norms (in a mixed sense, also descriptive), replacing the rule of law (in a normative sense only)[36] and to the constant judging of the environment based on the rule of "universal normativity" by virtually every person feeling such a vocation: a teacher, a doctor, a social worker. Foucault conceptualized the law in its operation as a multi-threaded and decentralized product of knowledge and social structures. For him, the law was part of the expansion of power, or rather – "authorities" clustered in many centers. In modern societies, law connects with power at many levels in various ways that expand patterns of social control, knowledge, and documenting information about an individual for institutionally

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34 J. Habermas, Theorie des komunikativen Handelns, Frankfurt 1981, p. 222.

35 G. Turkel, Michel Foucault: Law, Power and Knowledge [in:] Journal of Law and Society, Vol. 17, No. 2 (Summer, 1990), pp. 170-193. R.D. Rieke, Judicial Dialogue [in:] Argumentation 5/1991, Kluwer Academic Publishers. The Netherlands 1991, pp. 39-55.

36 F. Ost, Quelle jurisprudence pour quelle société? [in:] Dire le droit, faire justice, Bruylant, Bruxelles 2012, p. 16.

useful purposes. Ultimately, the requirement of legality and associated knowledge and control techniques cover every aspect of life, every fiber in the fabric of society. The source of "evil", or rather a perversion of noble intentions and ideas, was the evolution of Enlightenment ideas, "excluding forms of thinking, language, association, actions and experiences that are considered abnormal" Rules on coherence, i.e. deciding what is good and what is bad, true and false define the standard of normality. Normalizing discourses take place behind the façade of institutions dominating in social life in a given period, combining elements of rationality and science, juridical categories and state power, creating a network of knowledge and control patterns. The above statement shows the unprecedented power of the judges in the 21st century, which, along with the rapid expansion and sublimation of new technologies, offered unlimited possibilities for expanding knowledge to those chosen by humanity – the half-gods (compared, among others, to Hercules and Apollo, but also to Saint George). For this reason, this intellectual elite equipped with the weapons of independence and ultimate control of human behavior, including lawmaking by the legislature and its application by the executive, in terms of justice and efficiency, has become the target of unprecedented attacks (on the pretext of healing the justice system) by authoritarian regimes hatched on social discontent. The rebellion against social inequalities arises – which in a sense Foucault anticipated – out of powerlessness against exploitation by corporations strongly associated with power centers, the arrogance of the rulers and their distance from "ordinary people", which populists use skilfully. Instability in countries with seemingly ripe democracies is also associated with the effects of global warming and "peripheral" wars fueled by global powers: mass migrations of peoples towards a prosperous and more economically and climate stable north. Anti-immigrant policy is an extremely effect-ive scarecrow for some of even the most liberal societies and is part of the racist, anti-feminist and anti-ecological agenda of contemporary "conservatives" This is currently the biggest challenge for the courts, especially in post-communist countries, hence the attack on their independence by the other populist authorities is carried out with great determination. Strengthened by adequate algorithms, the „elite" now increasingly meaning strong non-national players with vast financial resources, may forward goals that are detrimental to rule of law and democracy. It is for the courts to defend these values also from abuse via information and communication technologies, conversely, using new AI-linked ICT for the benefit of global coherence and peace.

EUROPEAN PERSPECTIVE – THE EU AI WHITE PAPER

A recent document that sets the landscape for future legislative action is the EU Commission White Paper of 19 February 2020 on artificial intelligence: „A European approach to excellence and trust". The pre-legislative document

lists as AI benefits: improving health care (more precise diagnosis, better disease prevention), increasing the efficiency of agriculture, or transport; pro-ecological role in effectuating the „European Green Deal"; improving the efficiency of production systems and reduce the cost of holy services; increasing security (e.g. crime prediction) and improving the efficiency of public administration.

Among potential threats, the Commission enumerates: non-transparent decision making, discrimination based on sex or other protected features (Article 19 TFEU), interference with private life, possible use of AI for malicious and criminal purposes[37]. Hence the objectives of the EU White Paper entail a coordinated European approach to the social and ethical implications of artificial intelligence, better use of big data for innovation, regulatory and investment approach, promoting artificial intelligence, but also addressing threats (rule of law, basic laws), guaranteeing sustainable development (economic, ecological and social) identifying policy options on how to achieve these objectives, extensive public consultation (completed) and exclude military use from its scope[38].

The creation of the "Artificial Intelligence Ecosystem" for citizens comprises safe and environmentally friendly transport and health services. With respect to enterprises, the crucial problems are cybersecurity and green circular economy; while for services of general economic interest – reducing the costs of providing services (transport, education, energy and waste management). The problem of security of citizens in connection with rights and freedoms point at the benefits arising from the use of intelligent algorithms in tracking online terrorist propaganda or hate speech; detection of suspicious transactions of sale of dangerous products, money laundering; identifying dangerous hidden objects or illegal substances or products, assistance to citizens in emergency situations and assistance to emergency services. But disinformation, fake news, invasion of privacy and abuse of data, human dignity or the safety of minors are not to be neglected and call for comprehensive regulation[39]. An "ecosystem of excellence" along the entire value chain, from research and innovation to implementation is also stressed alongside the need for incentives for SMEs. An "ecosystem of trust" needs to be created, with the protection of fundamental rights at its core, including personal data (as stipulated in Art. 8 ECHR and CFR) and consumer protection (with respect to high-risk AI), which is utterly important for citizens.

With data wave increase from 33 zettabytes in 2018 to a forecast 175 zettabytes in 2025 (10 21 bytes)[40], 80% accounting for cloud computing, 20% for the

37 AI White Paper, p. 9.

38 Ibidem, p. 1.

39 M. Konopacka, Protection of Minors and Human Dignity in he Information Society: EU and US Perspectives [in:] Lawyers in the media society : the legal challenges of the media society / Saarenpää Ahti, Sztobryn Karolina (eds.), Rovaniemi 2019, University of Lapland Printing Centre, p. 127 et seq.

40 If every terabyte in the zettabyte was a kilometer, that would be the equivalent of 1,300 trips back to the Moon.

internet of things, including smart cars or home appliances, the basic requirements set out by the Commission cover data storage and record keeping; required types of information; reliability and accuracy; human supervision and specific requirements for certain artificial intelligence applications, e.g. for remote biometric identification. All the above safeguards serve the purpose of counteracting possible flaws within algorithms, including: early-stage machine learning mistakes, but also bias stemming from internalisation of prejudices of human creators, cybersecurity problems related to the Internet of Things[41], internet of bodies in the medical field[42], privacy and consumer protection concerns[43], military applications of autonomous robots[44], attempts at robots' rights regulations[45], intellectual property issues with respect to robots themselves, as well as the creations of artificial mind[46], civil and criminal liability for robots' actions and omissions[47], or – most reprehensibly – the singularity phenomenon potentially requiring efficient pre-emptive procedures designed to „press the red button" or „pull the plug"[48]. On the other hand, excessive or inadequate regulation may hinder headway, stifle innovation and sabotage potential AI benefits to humanity[49]. We are of the opinion that balance must be struck on all levels of governance, based upon relevant black-letter law regulations, as much as possible harmonized on

41 S. Kumar, P. Tiwari, M. Zymbler, Internet of Things is a revolutionary approach for future technology enhancement: a review, Journal of Big Data, volume 6, no.111/2019, SpringerOpen, p. 1-2.

42 H. Dalal Abdulmohsin et al., Body-to-Body Cooperation in Internet of Medical Things: Toward Energy Efficiency Improvement, Future Internet 2019, 11, 239; doi:10.3390/fi11110239, pp. 1-13.

43 S. Wang et al., Consumer Privacy Protection With the Growth of AI-Empowered Online Shopping Based on the Evolutionary Game Model, Frontiers in public health, 7 July 2021, Vol.9, pp. 1-9.

44 R. C. Arkin, Governing Lethal Behavior in Autonomous Robots, Chapman Hall/CRC 2009.

45 J. C. Gellers, Rights for Robots: Artificial Intelligence, Animal and Environmental Law, London : Routledge. 2021.

46 C. Castets-Renard, The Intersection Between AI and IP: Conflict or Complementarity?, IIC – International Review of Intellectual Property and Competition Law, 2020-01-21, Vol.51 (2), pp.141-143.

47 With respect, in particular, to manufacture and design defects and failure to warn. More on the subject: J. Villasenor, Products liability law as a way to address AI harms, 31 October 2019, https://www.brookings.edu/research/products-liability-law-as-a-way-to-address-ai-harms/ Accessed 15 August 2021. On postulated responsibility for plotting terror attacks see: M. Lavi, Do Platforms Kill?, Harvard Journal of Public Law Policy vol. 48, pp. 549-563.

48 In this respect, a question arises: will the future AI generate utopia or dystopia? „Although it is very unlikely that either scenario will ever occur, the potential impact can be so great that it deserves a certain measure of reflection. That applies both to the utopian vision (we never have to work again) and the dystopian vision (we will become slaves to technology)." R. van Belkom, AI no longer has a plug: About ethics in the design process. Part III in the series 'The future of artificial intelligence (AI)' Making choices in and for the future, The Netherlands Study Centre for Technology Trends (STT), The Hague 2020, p. 13.

49 J. von Braun et al., Robotics, AI, and Humanity: Science, Ethics, and Policy, Springer 2021.

a regional and – ideally – global scale, in order to avoid incoherent, chaotic and potentially dangerous developments and to prevent AI from working to the benefit of selected groups of society, serving their utilitarian purposes, or even from posing a threat to all human beings.

COMPARATIVE PERSPECTIVE – SOLUTIONS ADOPTED IN THE UNITED STATES

American solutions aimed at machine learning systems and AI refer to consumer protection and unfairness as defined in the Federal Trade Commission (FTC) act s. 5 (a)[50]. It covers substantial injury to consumers not reasonably avoidable by them and not outweighed by countervailing benefits. This expands to non-economic injuries and makes necessary due consideration for the established public policies and may be used against unfair uses of machine learning/AI. It is put forward by American authors addressing the subject, that ML/AI require a new paradigm based on social protection rather than on individual control[51]. However, some states' attempts at regulating AI (notably state privacy laws of Virginia and Colorado, while the draft Washington law was never passed) are referred to as „binary governance" covering two primary modes of regulation, the first one being the „individual rights approach" focused on dignity and autonomy, covering the right to meaningful information on used algorithms, he right to explanation, the right to human intervention and to express one's point of view as well as to contest supplemented by rights to notification, access, correction and deletion of personal data. The latter was also adopted in the EU in Art. 22 GDPR and advocated eg. by OECD in its 2019 Recommendations on AI, but also in the proposed amendments to Quebec law which includes the right to contest, or the Brazilian law with the right to review the decision taken with respect to unfair AI. The second possibility is the governance/compliance approach, which is more instrumental and offers systemic, ex ante control and ex-officio administrative supervision based on risk management. There is, however, growing tendency to combine the benefits of both approaches and to „co-regulate" the issue[52]. It is noteworthy that the US FTC is seeking to apply its own „unfairness authority" to use of biased algorithms, in accordance with the draft Algorithmic Fairness Act (p. 5052), focusing on algorithmic eligibility determinations with respect to key

[50] Section 5(a) of the FTC Act, 15 U.S.C. Sec. 45(a), prohibits, inter alia, "unfair methods of competition." Unfair methods of competition include any conduct that would violate the Sherman Antitrust Act or the Clayton Act.

[51] D.D. Hirsch, From individual control to Social Protection: New Paradigm for Privacy Law and the Era of Predictive Analytics, 79 Maryland Law Review 2020, p. 439.

[52] M. E. Kaminski, Binary Governance, 92 S. Cal L. Review 2019, p. 1529; M. E. Kaminski, Understanding Transparency in Algorithms Accountability, Cambridge Handbook of the Law of Algorithms, ed. Woodrow Barfield, Cambridge University Press 2020, pp.1-28.

life opportunities, such as employment or credit. A proposed Algorithmic Accountability Act refers to impact assessments as studies „evaluating an automated decision system and the automated decision system's development process, including the design and training data of the automated decision system, for impacts on accuracy, fairness, bias, discrimination, privacy, and security".

INTELLIGENT REGULATION: HUMAN MASTERS & ROBOT SLAVES OR VICE VERSA?

The „Ethics Guidelines for Trustworthy AI" „postulate that in order to achieve 'trustworthy AI', three components are necessary: (1) it should comply with the law, (2) it should fulfill ethical principles and (3) it should be robust". It should also operate and be used for ends consistent with core EU values of „respect for human dignity, freedom, democracy, equality, the rule of law and respect for human rights, including the rights of persons belonging to minorities" as enshrined in Article 2 TEU, common EU Member States' values as enshrined in the ECHR and the EU Charter of Fundamental Rights, but also in observance of the EU „regulatory framework that will set the global standard for human – centric AI", including the GDPR[53], the recently adopted Cybersecurity Act[54] and the proposed ePrivacy Regulation[55]. The seven key requirements enumerated in the Guidelines are: human agency and oversight , technical robustness and safety, privacy and data governance, transparency, diversity, non-discrimination and fairness, societal and environmental well-being and, finally, accountability. Intended as a horizontal policy of general application, these seven safeguards must take a „concrete and proportionate implementation, taking an impact-based approach"[56]. Design, drafting and passing adequate laws is rarely swift, therefore the judiciary may have to address novel legal issues. Practicing lawyers and academics alike are now tasked with strategic litigation and advancing test cases

[53] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation), OJ L 119, 4.5.2016, pp. 1–88.

[54] Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA (the European Union Agency for Cybersecurity) and on information and communications technology cybersecurity certification and repealing Regulation (EU) No 526/2013, OJ L 151, 7.6.2019, pp. 15–69

[55] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL concerning the respect for private life and the protection of personal data in electronic communications and repealing Directive 2002/58/EC (Regulation on Privacy and Electronic Communications), COM/2017/010 final – 2017/03 (COD).

[56] An example offered by the HLEG is that of AI application suggesting a consumer an unsuitable book to read compared to the much more perilous misdiagnosing patient's cancer or other health and safety applications, which call for far more stringent supervision.

preferably to last instance courts, that will in turn make sure to engage in European and perhaps even – much desired – global dialogue, while ascertaining more uniform and unavoidably creative interpretation of the emerging problems involved in AI activities.

AI can provide a system to make decision making more efficient: where humans make mistakes, AI may help to get the balance right. But should the administration of justice rely on the same mechanism as sports games where a video assistant referee decides if a player was off-side or not? This football analogy points to the phenomenon referred to as automation bias, where a logically flawless decision has no human element and therefore does not serve human justice, even with AI only aiding humans, as data judges receive through operation of AI is pre-filtered and inevitebly creates an information bubble. Any person, judge in particular, taking informed and unbiased decisions, must be capable of using the possessed contextual knowledge to analyse information; he or she must have adequate options and be free from coercion and manipulation of others. Another important question is that of collegiality – judges taking decisions in panels use the opportunity to exchange view and sometimes even, as pointed out by Posner[57], negotiate the outcome, where there are no guardians to guard pre-coded algorithms in their decision-making process. This refers us back to the black-box or explainability paradox on how base values were programmed, as a result of which a perfectly logical decision may also be perfectly unacceptable from the point of view of humanitarianism, and renders useful a remark coined by Donald Rumsfeld that we can never know the unknown unknowns. Human intelligence in this respect should face the challenge of treating artificial intelligence with due care and diligence, in order to oversee its development and make sure it remains an opportunity, not a threat.

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[57] R. Posner, Nine theories…, op. cit., pp. 31-34.

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Marek Grzybowski[1]

THE BALTIC SEA AND SPACE CLUSTER – PENTAGON HELIX HUB OF THE MARITIME AND SPACE INDUSTRY AND INTERNATIONAL PROJECTS HUB

The BSS Cluster is a Pentagon Helix HUB organisation. It integrates the transfer of knowledge between science and business, supports social initiatives, local governments and administration, develops investor relations in the maritime and space industry. The cluster acts as a smart organisation. We view maritime and space business in a holistic manner. BSSC integrates technological, legal and economic solutions at the scientific, business and social level.

The Baltic Sea and Space Cluster is unique on a global scale. The Cluster was established on July 27, 2009. We started the incubation process of the cluster in 2000. After several years of incubation, the cluster began to operate in the *Triple Helix* formula. After a few years, as a result of participation in numerous international projects, it evolved into a *Quadralupe Helix* cluster. Today, the cluster works in the *Pentagon Helix* formula. It integrates the transfer of knowledge between science and business, supports social initiatives, local governments and administration, develops investor relations. The cluster acts as a smart organisation. We view maritime and space business in a holistic manner. We integrate technological, legal and economic solutions at the scientific, business and social level. *The* Baltic Sea and Space Cluster (previously: Polish Maritime Cluster) is an active member of the United Nations Global Compact and operates on the European Cluster Colla-

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boration Platform. It is a key maritime cluster in Central and Eastern Europe, an important cluster in the Baltic Sea Region and the European Union, a recognisable cluster on the global maritime economy market, as evidenced by partner cooperation with clusters operating in the United States, Asia and South Africa.

BALTIC SEA REGION OBSERVATORY

The Baltic Sea Region has the highest innovation level in the European Union. Sweden, Finland, Denmark and Germany are the leading economies in this area. Estonia and Poland belong to a group of moderate innovators while Lithuania and Latvia show little activity in this field. The same applies to Leningrad and Kaliningrad regions. A lot of innovations is introduced in maritime industries. The Baltic Sea Region Observatory monitors changes in the region and works on projects that aim to diminish the innovation gap in the area. We support transformation into more ecological and more resilient communities and economies through international cooperation.

In the Baltic Sea Region, clusters developed most intensively in the Scandinavian countries. In many cases, cluster initiatives have allowed for radical change in the region's production offer. For example, in Gothenburg, the development of cooperative relationships has contributed to the growth of automotive and telematics industries. A strong Medicon Valley operates in Denmark and Sweden. Located at the gateway to Denmark and Sweden it has a strong ecosystem and deep talent pool underpinned by world-class life science universities and research infrastructure. The strong Norwegian oil & gas offshore cluster has weakened due to low oil and gas prices. The Norwegian fish farm cluster is still a world market leader. The strong Danish Maritime Cluster has the support of A.P. Moller – Maersk, the leader on the maritime container transport market.

THE POLISH MARITIME CLUSTER AS THE PREDECESSOR OF THE BSSC

The PMC (now BSSC) has been strongly based in seaports, shipyards, the Pomeranian Special Economic Zone and innovative companies involved in the production and services within the maritime (and now also space) industry. Research and education are an important part of the cluster's activity. In the area of the former Gdynia Shipyard, the production profile was changed. Instead of simple vessels for container, ro-ro ships and bulk carriers, specialised vessels worth EUR 200 million are being built for the offshore industry, as well as research and special vessels. For example, in 2012, the most modern wind farm construction unit in Europe was built, and in 2014 the first electric ferry in the world was constructed. Ships were built also by Crist shipyard, a BSSC member.

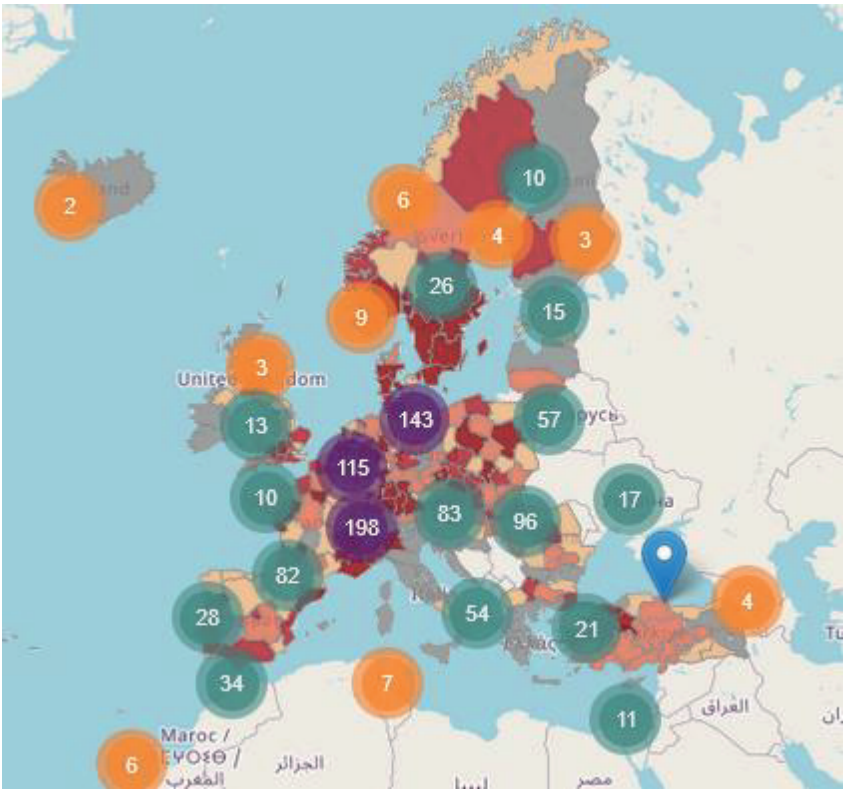

Figure 1. Clusters in Europe
Source: clustercollabration.eu

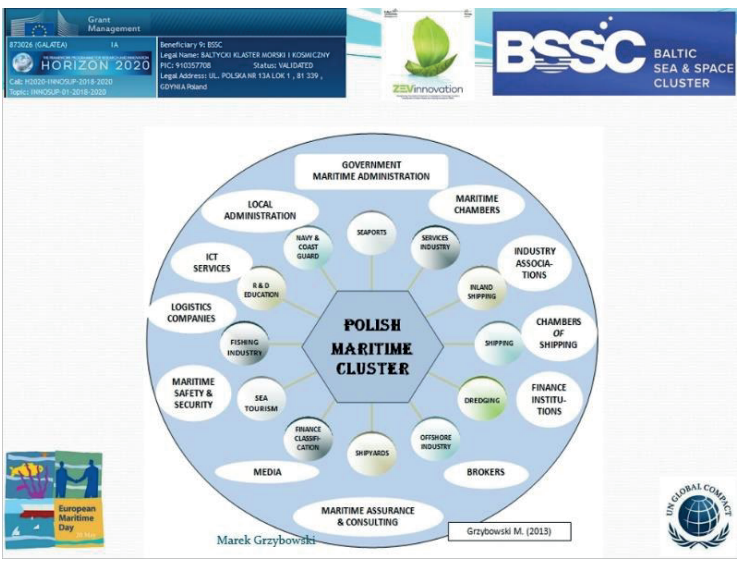

Figure 2. Polish Maritime Cluster (currently: Baltic SeaSpace Cluster)
Source: Marek Grzybowski

The BSSC operates in the form of an association under the Law on Associations; in addition, it operates on the basis of the Association's Statute, according to which the Cluster's duties include in particular:

1. supporting innovation and development in the field of research, involving entrepreneurs, central administration and local government, on issues related to the Baltic Sea Region together with land-water facilities along the Vistula River, fostering economic and social ties between Pomerania and the rest of Poland with the other countries of the Baltic Sea Region and acting as a coordinating institution by:

– creating a cooperation network of enterprises, local authorities, universities and business environment institutions,
– increasing the innovation and integration capacity of maritime enterprises and the Vistula Catchment Area, supporting the construction and development of innovative and competitive hubs, creating conditions for effective commercialization of research results of universities and R&D units,

2. consulting for enterprises, developing innovative technologies, supporting economic initiatives and preventing unemployment,
3. development of professional qualifications and skills of those working for the needs of the regional economy,
4. participation in European and global organisations, in particular in the organisation of European clusters,
5. participation in the implementation of the priorities and activities of the European Union Strategy for the Baltic Sea Region in the area of the cluster's operation,
6. developing the economic and logistic potential of the VI Pan-European Transport Corridor by cooperating with interested local authorities and economic associations, including the Association of Cities of the Amber Highway based in Gdynia,
7. participation in international fairs and other events.
8. co-creating the Polish maritime policy,
9. conducting information, education and lobbying activities in order to increase Pomeranian Voivodeship's attractiveness for investors,
10. ensuring the flow of information between Cluster members.

At the General Meeting of the Polish Maritime Cluster on June 28, 2018, a decision was made to expand the operations and create a Baltic Maritime and Space Cluster. Support for the cluster was declared by the Space Sciences Commission of the Polish Academy of Sciences and the Student Maritime and Space Cluster of the University of Business and Administration. Committees and chairman of the think-tank were appointed. The following Committees operate within the Cluster: – for maritime affairs; – for space affairs; – for law; – for education; – for smart specialisations; – for inland shipping.

BALTIC SEA AND SPACE CLUSTER – HUB OF PROJECTS

The decision to expand and create the Baltic Sea and Space Cluster proved to be proper. Support of the Space Science Committee of the Polish Academy of Sciences was efficient. The Student Maritime and Space Cluster of the University of Business and Administration was also active. Soon, on the international arena, the Baltic Sea & Space Cluster became a recognisable brand.

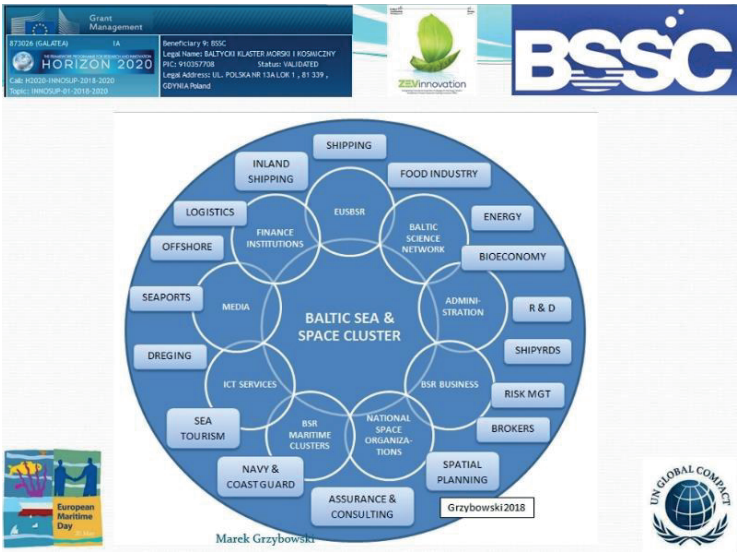

Figure 3. Baltic Sea and Space Cluster
Source: Marek Grzybowski

The cluster participates or is a partner in international projects conducive to the development of innovative regions and knowledge transfer, focusing on implementation of innovations in the maritime and space industries:

1. *GALATEA* [HORIZON 2020] – grow and accelerate your smart projects in new value chains of the European Blue Economy
2. ZEVinnovation project aims to establish a sustainable and efficient network for the development of innovative technologies
3. TENTacle – capitalising on TEN-T core network corridors for prosperity, growth and cohesion
4. ECOPRODIGI – eco-efficiency to maritime industry processes in the Baltic Sea Region through digitalisation
5. ELMAR – supporting South Baltic SMEs to enter the international supply chains & sales markets for boats & ships with electric propulsions
6. SMART BLUE REGIONS – seeks to enhance blue growth opportunities based on increased capacity of Baltic Sea Regions to implement Research and Innovation Strategies for Smart Specialisation (RIS3).

7. E-LASS – European network for lightweight applications at sea
8. InterMarE – strengthening the international activity of blue sector SMEs in the South Baltic Sea area
9. UMBRELLA – helps boosting cross-border cooperation capacities of Local Actors in the South Baltic Sea

GALATEA is currently one of the most important projects in which the cluster participates. It is an INNOSUP project, that is a cascade funding mechanism operated by clusters impacting a large number of SMEs. Indeed, 75% of the total budget of the project has to be redistributed to projects led by SMEs. It is a first simplified experience for SMEs to access EU funding.

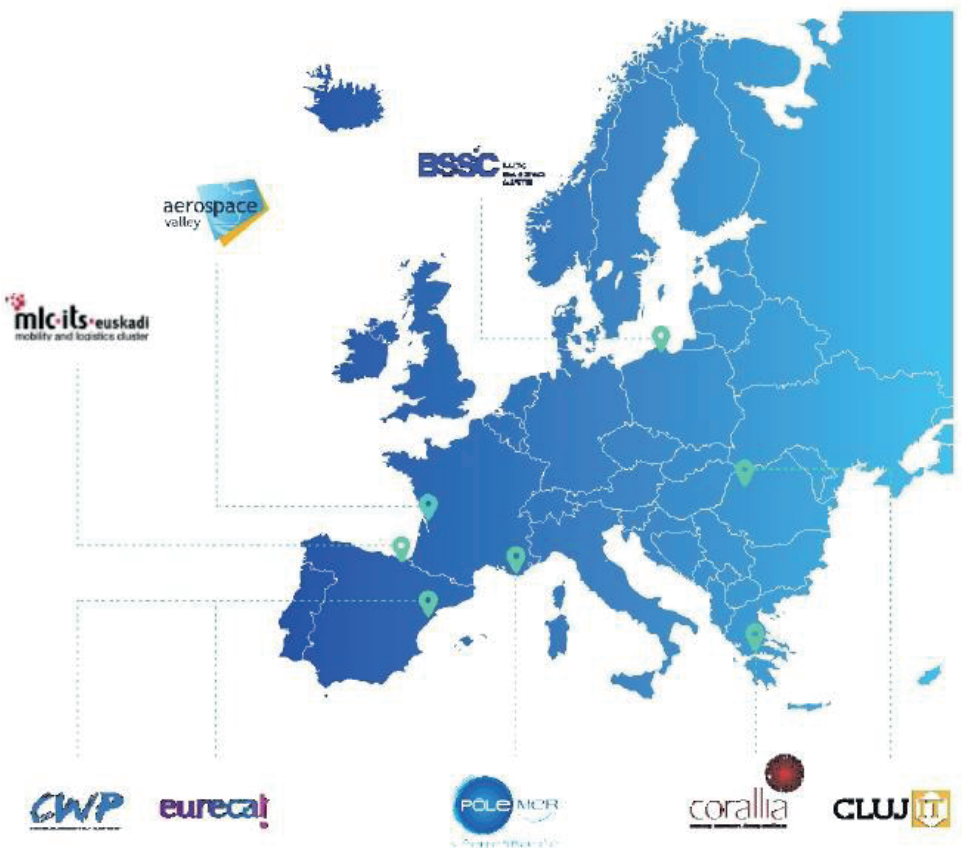

Figure 4. GALATEA Project partners map
Source: GALATEA Project

GALATEA's overall objective is the development of new cross-sectoral and cross-border industrial value chains, supporting in particular innovative SMEs, which should be facilitated by clusters. It also aims at fostering the development of Blue Growth key industries in Europe to be competitive at the global level. This

development will be based on the construction of new industrial value chains and the reconfiguration of existing ones driven by the integration of technologies and know-how from aerospace and ICT communities to the following Blue Growth domains: ports, ships, shipyards and maritime surveillance. The project is led by Pôle Mer Mediterranée.

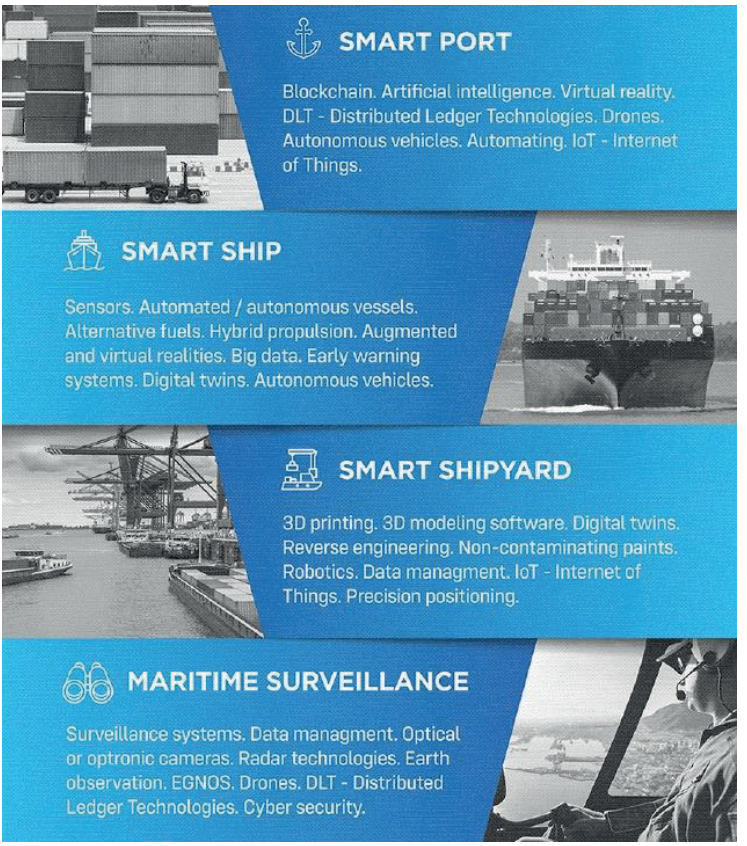

Figure 5. GALATEA Project area activities
Source: GALATEA Project

The task of GALATEA in a more concrete form is to create new bridges between actors from different sectoral and cultural ecosystems. SMEs' owners and their teams are facing new difficulties to keep their businesses afloat, For this reason we plan services regrading notably internationalisation of the businesses or even sustainability of the projects developed through GALATEA[1].

[1] Marek Grzybowski Interview with Clémence Le Corff and Diego Carballo: GALATEA – new cross-sectoral and cross-border industrial value-chains in the Blue Economy https://www.eblueeconomy.com/interview-galatea-new-cross-sectoral-and-cross-border-industrial-value-chains-in-the-blue-economy/ ExclusiveHomeInterviews

There are three steps aiming to support SMEs in their innovation development:

- Identification of needs: GALATEA will discuss with end-users from the 4 targeted domains in order to identify their needs and the challenges they represent for SMEs;
- Emergence of projects: through 2 different events, GALATEA will favor the discussions between SMEs and the emergence of project ideas to be submitted to the GALATEA Open Calls;
- Innovation support: GALATEA has launched a Call for vouchers and a Call for services aiming to select high-potential SMEs and support them in the development of their innovation projects.

Innovation Clubs aimed to create an open place where SMEs could meet between each other and exchange with experts from the maritime field. By using a Design Thinking methodology, within GALATEA Innovation Clubs, SMEs were able to brainstorm about the various challenges and suggest some innovative ideas on how to tackle these challenges. As the Innovation Clubs brought actors from various sectors, it was as well a place where complementarity between skills and experiences could be found.

Another BSSC joint undertaking, the **ZEVinnovation project,** aims to establish a sustainable and efficient network for the development of innovative technologies. The project's mission is to bring together professional stakeholders interested in innovative zero-emission technologies and provide lasting and tailor-made solutions that will eventually increase innovation ability across the EEA. The ZEVinnovation project aims to establish a sustainable and efficient network for the development of innovative technologies that will bring together active stakeholders.

Figure 6. ZEVinnovation Project Partners
Source: Marek Grzybowski

The ZEVinnovation network's ambition is to contribute to the strengthening of the transnational eco-system through the implementation of pilot programmes focusing on the collaborative development and market uptake of zero-emission

vessels while connecting the capacities of the EEA countries that have a strong maritime tradition and current pioneering initiatives. The project is implemented by multi-sectoral partners from Croatia, Norway and Poland: Center of Technology Transfer LLC (Croatia), Baltic Sea and Space Cluster (Poland), Inovacije i razvoj LLC (Croatia), ÅKP AS (Norway) and Vinco Innovation AS (Norway). Regardless of the differences in size and population, partner countries face common environmental challenges concerning resource limitations and vulnerability to climate changes. Transnational partners of the ZEVinnovation project are devoted to supporting enterprises across the EEA through networking and helping them achieve their growth ambitions through a diverse range of project activities[2].

Figure 7. ZEVInnovation Project HUB Idea
Source: ZEVInnovation Project

7 technologies allow the use of propulsion, which is supposed to enable sailing without CO_2 emissions to the environment. Experts say that we have at our disposal: an electric drive, a hydrogen-powered hybrid power plant, hydrogen fuel cells, a hydrogen + ICE, ammonia as a fuel source in combination with fuel cells or a diesel engine, as well as biofuel.

Alcohol, biomethane and ammonia are fuels that make it possible to achieve zero emissions of harmful substances in the exhaust gases of ships. These are the

[2] Marek Grzybowski interview with Boris Cosic Director Center of technology transfer IIC, https://www.eblueeconomy.com/interview-boris-cosic-implementation-of-pilot-programs-focusing-on-the-collaborative-development-and-market-uptake-of-zero-emission-vessels/

research results contained in the latest report by A.P. Moller—Maersk and Lloyd's Register – the result of studies from more than two years ago, when marine fuel was much more expensive than today. 80% of respondents believe that the maritime transport market needs zero-emission vessels (ZEV).

ECOPRODIGI is another important project in which the cluster participates. The project increases eco-efficiency in the Baltic Sea region maritime sector by creating and piloting digital solutions in close cooperation between industry end-users and research organisations. Ultimately, ECOPRODIGI supports the Baltic Sea region in becoming a front-runner in maritime industry digitalisation and clean shipping. ECOPRODIGI addresses both the environmental and economic challenges by increasing eco-efficiency at all stages of the vessel lifecycle from design and building to the use, maintenance, stowage, as well as conversion processes. In practice, ECOPRODIGI not only provides highly needed information about the key eco-inefficiencies of the industry, but also precisely develops and pilots digital solutions to better measure, visualise and optimise the industry processes (more info: https://ecoprodigi.eu/).

The **TENTacle is a project** of the city of Gdynia whose implementation was supported by the BSSC Think Tank. It was the new flagship project of the EU Strategy for the Baltic Sea Region. One of the Gdynia main aims of participating in the project was to analyze the needs related to the transport node's development in the city. The TENTacle project was to help define the type of infrastructure and services necessary for the better and faster development of Gdynia and the entire Baltic Sea Region, and to identify what actions to take to maximise the advantage of the seaside location of the city.

– *The project helped acquire a great deal of knowledge that will allow to disseminate all activities related to transforming Gdynia into the TEN-T core network node by 2030* – explains Ryszard Toczek, TENTacle project manager in Gdynia. – *It was an introduction to the preparation and implementation of 23 investments implemented as part of the Baltic-Adriatic corridor's construction in Gdynia* (more: http://tentacle.eu/).

The **ELMAR** project aims to support SMEs in creating international supply chains as well as accessing foreign sales markets for boats and ships with electric propulsions. The project consortium consists of partners from Germany, Poland and Lithuania, representing regional development agencies, scientific institutions, branch associations of the yacht technology suppliers, owners of historical ships as well as electric boat producers[3].

The cluster is also a partner of many international and local conferences where issues related to the implementation of innovative solutions in maritime economy are raised. The TRANSOPOT conference, the annual European Union Strategy Forum for the Baltic Sea Region and other similar events have been included in the annual calendar.

[3] http://electric-water-mobility.eu

Scientific conferences with the participation of practitioners and startups are extremely successful initiatives of the Baltic Maritime and Space Cluster. They were implemented with the support of the Space Sciences Committee of the Polish Academy of Sciences and the Institute of Oceanology of the Polish Academy of Sciences. Conferences were also organised by universities from Pomerania: the College of Administration and Business, the Naval Academy, Gdańsk University of Technology and the University of Gdańsk.

The following conferences were held in the years 2018-2021:

- 09-11-2017 – Space Cluster. Intelligent Specialisation? Risk management, finance and insurance in space projects – University of Business and Administration in Gdynia.
- 08-03-2018 – Space and Sea, Institute of Oceanology, Polish Academy of Sciences, Sopot
- 20-09-2018 – Baltic Sea & (Outer) Space New perspective for our region, Institute of Oceanology, Polish Academy of Sciences, Sopot
- 22-11-2018 – Seaport + Space Infrastructure Synergic Network under common management, University of Business and Administration in Gdynia.
- 19-03-2019 – Autonomous ships. Inevitable reality at sea, Gdansk University of Technology.
- 18-05-2019 – Institutional Cooperation at Sea & (Outer) Space Essential adjustments needed to boost full potential, Gdańsk University, Law and Administration Faculty.
- 19-09-2019 – Remote sensing. Challenges in gather and sharing data Conference, Naval Academy Gdynia
- 14-11-2019 – Sea and underwater drones – Unidentified Sea Objects, Naval Academy, Gdynia
- 24-09-2020 – Smart Port. The merged sea & space network, Baltic Sea & Space Cluster, Space Sciences Committee Polish Academy of Sciences / Gdańsk Branch and Polish Space Agency (POLSA) -Gdynia – University of Business and Administration in Gdynia
- 19-11-2020- Artifical Intelligence. In search for synergy, Technical University of Gdańsk, Baltic Sea & Space Cluster, Space Sciences Committee Polish Academy of Sciences / Gdańsk Branch and Polish Space Agency (POLSA)
- 11-03-2021 – Baltic Sea. Reflection of the stars, Institute of Oceanology, Polish Academy of Sciences, Sopot
- 20-05-2021 – Launch of the Polish Space Rocket, Pomeranian University, Słupsk
- 23-09-2021 – Maritime and space safety, University of Gdańsk
- 18-11-2021 – Cosmos. Dialog between West and East, University of Warsaw

Figure 8. BSSC Conference in GDYNIA NAVAL ACADEMY
Source: BSSC

Successful strategic activities include B2B meetings organized by the Baltic Sea and Space Cluster. So far, fruitful meetings have taken place in many ports, shipyards, design offices and manufacturing plants related to maritime and space industries. In Poland, as an expert, PKM operates in the smart specializations of Pomerania. ISP1 – Offshore and port-logistics technologies; "maritime" specialisation, which includes: ship and offshore construction (e.g. placing offshore wind farms), logistics in ports and at their hinterland, use of biological resources of the sea. ISP 2 – Interactive technologies in the information environment, specializing in "ICT", i.e. information and communication technologies, including: ICT solutions for production and services, ICT tools for managing urban space, management of large data sets, business use of satellite technologies. The BSSC was the initiator of the creation and development of the national smart maritime specialization. Innovative marine technologies in the area of specialized vessels, marine and coastal constructions as well as maritime and inland logistics and transport.

The positive attitude of companies' CEOs, board members and employees to cooperation for the benefit of Polish maritime and space technologies gives measurable marketing effects and contributes to the synergy effect resulting from cooperation between business, administration and science. The members of the Baltic Maritime and Space Cluster in the recent years have strengthened their position on the international market, integrated their activities on the national and international forum by participating in international fairs and conferences, supporting the transfer of knowledge between business and science. One of the most important achievements of our cluster members is active participation in the creation of intelligent maritime specializations in Pomerania.

Marek Grzybowski,
President of the Board, Polish Nautical Society, Baltic Sea and Space Cluster