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Надійшла до видання 03.02.2026.
Прийнята до друку після рецензування 10.03.2026.

DOI: 10.15421/272606
UDC 17:62:001.1:141.7:82–312.9(4–11)

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THE ETHICAL HORIZON OF THE TECHNOSPHERE: A HOLISTIC CHAIN OF RESPONSIBILITY OF THE COGNITIVE AGENT IN EASTERN EUROPEAN TWENTIETH-CENTURY SCIENCE FICTION

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Abstract. The aim of the article is to identify and conceptually analyze the ethical horizon of the technosphere within the context of twentieth-century Eastern European science fiction as an alternative to normative models of science and technology ethics. The article substantiates the thesis that within the Eastern European intellectual tradition, stable preconceptions of the responsibility of the cognitive agent have emerged – preconceptions that cannot be reduced to formalized ethical codes or algorithmic prescriptions but possess a holistic, anthropological, and existential-systemic character. The research methodology is based on the principles of interdisciplinarity, holism, and historical-philosophical analysis, with the use of science fiction as a form of thought experiment in the history of ideas concerning science and technology. An analytical reconstruction of models of responsibility represented in the works of Eastern European authors is applied, with particular attention to anti-normative, anthropoethical, existential-systemic, and cybernetic dimensions of interpreting the technosphere. The study shows that in twentieth-century Eastern European science fiction, the technosphere appears as a holistic environment of meanings, goals, and consequences of scientific and technical activity, within which the responsibility of the cognitive agent cannot be delegated to technical systems or removed through normative formalization. Invariant features of ethical thinking have been identified, related to the priority of goal setting over rules, awareness of the limits of control, and

acceptance of the «cost of error» as an ethically significant factor. The scientific novelty of the article stems from the substantiation of the concept of the ethical horizon of the technosphere as a dynamic horizon of responsibility, as well as from the demonstration of the heuristic productivity of Eastern European science fiction for contemporary philosophy of science and technology. The obtained results are relevant for the further development of artificial intelligence ethics, engineering ethics, and philosophical-pedagogical approaches to the formation of responsibility in subjects of scientific and technological activity.

Keywords: technosphere, ethical horizon, responsibility of the cognitive agent, philosophy of science and technology, normativism, science fiction, holism, Eastern European intellectual tradition.

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ЕТИЧНИЙ ОБРІЙ ТЕХНОСФЕРИ: ХОЛІСТИЧНА ЛІНІЯ ВІДПОВІДАЛЬНОСТІ СУБ'ЄКТА ПІЗНАННЯ У СХІДНОЄВРОПЕЙСЬКІЙ НАУКОВІЙ ФАНТАСТИЦІ XX СТОЛІТТЯ

Анотація. Метою статті є виявлення та концептуальний аналіз етичного обрію техносфери в контексті східноєвропейської наукової фантастики XX століття як альтернативи нормативістським моделям етики науки й техніки. У статті обґрунтовується теза про те, що в межах східноєвропейської інтелектуальної традиції сформувалися стійкі передконцепти відповідальності суб'єкта пізнання, які не зводяться до формалізованих етичних кодексів або алгоритмічних приписів, а мають холістичний, антропологічний та екзистенційно-системний характер. Методологія дослідження ґрунтується на принципах міждисциплінарності, холізму та історико-філософського аналізу, із залученням наукової фантастики як форми мисленнєвого експерименту в історії ідей науки і техніки. Застосовується аналітична реконструкція моделей відповідальності, представлених у творчості східноєвропейських авторів, із виокремленням антинормативних, антропоетичних, екзистенційно-системних і кібернетичних вимірів осмислення техносфери. У результаті дослідження показано, що у східноєвропейській науковій фантастиці XX століття техносфера постає як цілісне середовище смислів, цілей і наслідків науково-технічної діяльності, у межах якого відповідальність суб'єкта пізнання не може бути делегована технічним системам або знята шляхом нормативної формалізації. Виявлено інваріанти етичного мислення, пов'язані з пріоритетом цілепокладання над правилами, усвідомленням меж контролю та прийняттям «ціни помилки» як етично значущого чинника. Наукова новизна статті полягає в обґрунтуванні поняття етичного обрію техносфери як динамічного горизонту відповідальності, а також у демонстрації евристичної продуктивності східноєвропейської наукової фантастики для сучасної філософії науки і техніки. Отримані результати мають значення для подальшого розвитку етики штучного інтелекту, інженерної етики та філософсько-педагогічних підходів до формування відповідальності суб'єкта науково-технічної діяльності.

Ключові слова: техносфера, етичний обрій, відповідальність суб'єкта пізнання, філософія науки і техніки, нормативізм, наукова фантастика, холізм, східноєвропейська інтелектуальна традиція.

Introduction. In the twentieth and twenty-first centuries, the rapid development of science, technology, and artificial intelligence has intensified the problem of the ethical responsibility of the cognitive agent under conditions of an increasingly complex technosphere. For a long time, the dominant strategy of ethical reflection on technological progress remained the normative approach. Normativism in the field of the ethics of technology proceeds from the assumption that moral risks associated with the use of technical systems can be minimized or eliminated through the introduction of clearly defined norms, instructions, and algorithms. This approach proved particularly attractive in the context of the development of automated and autonomous systems, as it created the illusion that ethical responsibility could be transferred from the human subject to a formalized regulatory mechanism. Within

the normative framework, the technosphere appears as a space subject to regulation by external rules, while questions concerning the meaningful foundations of technical activity, the goals of scientific cognition, and the anthropological consequences of technological decisions remain secondary.

A classic artistic expression of the normative logic in the interpretation of technical rationality is constituted by the «Three Laws of Robotics» proposed by Isaac Asimov (1942). In a series of short stories and novels united under the Robot series cycle, the author consistently explores the possibility of programming the moral behavior of artificial agents through a system of universal prescriptions[1]. The Three Laws of Robotics, and subsequently the formulated Zeroth Law, perform in these texts the function of a normative framework designed to guarantee human safety and the stability of social order amid the growing autonomy of machines. At the same time, Asimov's literary experiment itself reveals the internal tension of this model: conflicts between the laws, the unforeseen consequences of their literal execution, and the necessity of constant human intervention point to the fundamental limitations of algorithmic ethics. Ultimately, the very internal logic of normativism imposes a number of essential constraints: rules are always derivative of human goal-setting; they are incapable of encompassing all possible situations of interaction within complex systems; and they do not eliminate the question of the source and limits of responsibility borne by the subject who formulates these rules. It is precisely the reduction of ethics to formal control over the behavior of agents that generates the need for alternative models of conceptualizing the technosphere – models capable of accounting for the wholeness of human experience and the responsibility of the cognitive agent for the technical reality it creates.

In contemporary discussions, particular significance is attached to the conceptualization of the technosphere as a holistic environment in which knowledge, values, social institutions, and the existential consequences of human choice are intertwined. As philosophers and scholars of the interaction between humanity and technology note, «*Technology, as a collection of certain material objects, is, figuratively speaking, a useless «pile of iron», and only after the «revival» of a public person, it becomes an effective tool for connecting the society with the environment. And only in total all these factors are subject to study both for understanding the driving forces of history and for prognostic purposes*»[2]. It is precisely this holistic perspective that makes it possible to pose the question of the ethical horizon of the technosphere – that is, the totality of meaningful and axiological boundaries within which scientific cognition and technical creativity acquire a moral dimension. By the ethical horizon of the technosphere, this study means the set of value-laden, semantic, and practical limits within which scientific and technological activity acquires moral significance and gives rise to questions of responsibility. The dynamic horizon of responsibility, in turn, refers to the fact that the boundaries of responsibility are not fixed once and for all by an external code, but are continuously specified by the type of technical situation, the scale of consequences, the degree of human control, and the character of goal-setting.

In Western European thought, the ethics of science and technology throughout the twentieth century was to a considerable extent institutionalized in the form of academic normative discourse and frequently interpreted technology either as an ontological mode of revealing or as an autonomous systemic force[3]. At the same time, an alternative line of reflection acquired particularly explicit articulation within the Eastern European intellectual space, where questions concerning science, technology, and their limits were long explored within an artistic-philosophical framework. In this environment, science fiction functioned as a distinctive «laboratory of thought,» within which possible scenarios of the development

[1] Asimov I. Runaround. Astounding Science-Fiction. 1942. Vol. 29. No. 1. March. P. 94–103; Asimov I. Robots and Empire. New York: Doubleday, 1985. 448 p.

[2] Griffen L., Ryzheva N., Nefodov D., Hryashchevskaya L. Some methodological issues of the history of science and technology. *History of Science and Technology*. 2022. Vol. 12. No. 1. P. 35.

[3] Heidegger, M. The Question Concerning Technology. In: The Question Concerning Technology and Other Essays. New York: Harper & Row, 1977. P. 3–35; Ellul, J. The Technological Society. New York: Knopf, 1964. 449 p.

of the technosphere were examined through the prism of human responsibility, moral choice, and the transformation of the cognitive subject. In this context, technology was perceived not merely in utilitarian terms – as a means of satisfying needs or as an instrument of social organization – but as a domain requiring anthropological and ethical interpretation.

Within this approach, technological complexity appears not only as a structural condition of modernity but as a factor of ethical intensification: as systems become increasingly autonomous and cognitively sophisticated, the moral burden placed upon the human subject correspondingly grows. Such a perspective does not negate ontological or critical interpretations of technology; rather, it complements them by foregrounding responsibility under conditions of systemic risk, epistemic limitation, and expanding technological agency. This allows the technosphere to be understood as a space in which scientific and technical activity emerges simultaneously as both the product and the catalyst of humanity's moral and psychological reflection, the traces of which can be discerned in literature and art.

The choice of the Eastern European corpus of twentieth-century science fiction is motivated not only by literary but, above all, by cultural-historical and philosophical factors. The authors included in the analysis were shaped within an intellectual space that inherited the tradition of humanistic and moral-anthropological reflection on science, established in Eastern European and post-imperial culture of the nineteenth and early twentieth centuries. For this reason, engagement with Eastern European science fiction of the twentieth century makes it possible to reconstruct preconceptions of ethical responsibility that cannot be reduced to normative regulation, but instead possess an ontologically and anthropologically charged character. Within the framework of the proposed study, science fiction is regarded not as illustrative or popularizing material, but as a specific source in the history of ideas concerning science and technology. Its heuristic potential lies in the fact that it functions as a form of intellectual experiment, within which boundary situations in the development of the technosphere are modeled, the possibilities of rational control over technical systems are tested, and the hidden anthropological and ethical consequences of scientific-technological progress are revealed. It is precisely for this reason that twentieth-century science fiction makes it possible to reconstruct not completed ethical theories, but preconceptions of responsibility that precede their academic formalization.

In this article, the technosphere is understood not in the narrow sense as a mere aggregate of technical devices, but in an expanded historical-philosophical sense as a holistic space of scientific and technological activity that includes technical systems, human goal-setting, institutional forms of control, and the horizons of consequences generated by technical action. Eastern European science fiction became a particularly important medium of reflection because, within the cultural conditions of accelerated modernization, strong worldview investment in scientific progress, and collective projects of the future, it functioned not only as a literary genre but also as a space for conceptual experimentation with the limits of knowledge, intervention, and responsibility.

Thus, **the object** of this study is the work of Eastern European science fiction writers of the twentieth-century as a special space for understanding science, technology, and responsibility under the conditions of the formation of the technosphere. **The subject** of this study is the models of responsibility of the cognitive agent (subject) in the technosphere, reconstructed on the basis of the literary texts of science fiction writers of Eastern Europe of the twentieth-century, and above all, the conceptualization of the technosphere as a holistic field of moral-ethical responsibility.

Thus, **the purpose** of this article is to identify and analyze, on the basis of primary sources and scholarly literature, the holistic line of ethical responsibility of the cognitive agent in the conceptualization of the technosphere, drawing on the material of twentieth-century Eastern European science fiction, as well as to substantiate the concept of the «ethical horizon of the technosphere» as an alternative to the normative model of «code-based ethics.» This involves addressing the following research objectives: first, to delineate the conceptual boundaries of the normative approach to the ethics of science and technology and to demonstrate its role in shaping conceptions of the moral regulation of the technosphere; second, to justify the use

of science fiction as a source for the historical-philosophical analysis of preconceptions of ethical responsibility in the domain of science and technology; third, to reconstruct the key models of responsibility of the cognitive agent in the works of twentieth-century Eastern European authors; fourth, to show how the «cybernetic layer» of Soviet science fiction reinforces and concretizes the ethical problematic of responsibility under conditions of technical complexity; fifth, to synthesize the obtained results within a holistic framework and to propose an interpretation of the ethical horizon of the technosphere as a meaningful and axiological horizon of scientific-technological activity. In this study, responsibility is understood primarily as moral-anthropological responsibility: the responsibility of the cognitive agent for the setting of goals, the limits of permissible intervention, the control of consequences, and the acceptance of the cost of error. Legal and institutional forms of responsibility are acknowledged, but they are treated here as derivative of this more fundamental level.

Analysis of Recent Research and Publications. In recent years, the problematics of the ethical interpretation of the technosphere and the responsibility of the cognitive agent have been actively developed within contemporary philosophical and interdisciplinary discourse. Normative approaches to the ethics of technology and artificial intelligence are represented in the works of W. Wallach and C. Allen[4], S. Russell[5], as well as in H. Jonas's[6] concept of the «imperative of responsibility.» The critique of the algorithmic reduction of morality and the emphasis on the impossibility of fully formalizing ethical judgment are elaborated in the works of J. Weizenbaum. In the Eastern European intellectual context, the holistic conceptualization of science and technology is presented in the works of I. Tsekhmistro[7], L. Griffen[8] and N. Ryzhova, who emphasize the cultural and anthropological conditioning of technical activity. A separate line of research is associated with the analysis of science fiction as a form of philosophical reflection on science and technology, as reflected in the works of N. Chumarova[9], J. Gerhard[10], R. Krzanowski and P. Polak[11]. At the same time, the problem of forming a coherent value-ethical horizon of the technosphere – as a unity of meaning, goal-setting, and the moral responsibility of the cognitive agent – has not yet received systematic generalization. It is precisely this deficit of a holistic, internally grounded (rather than purely normative) ethics that determines the relevance of the present study.

Sources and Research Methods. The methodology of this study relies on historical-philosophical, comparative, and interdisciplinary analysis, combined with a holistic approach, as well as conceptual reconstruction, using a conditional analytical matrix for the interpretation of models of responsibility in the technosphere on the basis of the literary texts of visionary science fiction writers. During the preparation of the manuscript, artificial intelligence tools and digital language services (ChatGPT, Gemini, Microsoft Copilot, and LanguageTool) were used for language and stylistic editing, clarification of selected formulations, and technical verification of the text.

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[4] Wallach W., Allen C. Moral Machines: Teaching Robots Right from Wrong. Oxford: Oxford University Press, 2008. 288 p.

[5] Russell S. Human Compatible: Artificial Intelligence and the Problem of Control. New York: Viking, 2019. 352 p.

[6] Jonas H. The Imperative of Responsibility: In Search of an Ethics for the Technological Age. Chicago: University of Chicago Press, 1984. 255 p.

[7] Цехмістро І. З. Холістична філософія науки: навчальний посібник. Суми: Університетська книга, 2002. 364 с.

[8] Гріффен Л. А. Феномен техніки: монографія. Київ: Центр пам'яткознавства НАН України і УТОПІК, 2013. 252 с.

[9] Chumarova N. Ivan Efremov's Andromeda Nebula: the turning point of Soviet science-fiction literature. Bohemica litteraria. 2015. Vol. 18. No. 2. P. 29–43.

[10] Gerhard J. Representation of History in the Brothers Strugatsky's Novel Hard to Be a God. Journal of Science Fiction. 2018. Vol. 2. No. 4. P. 9–24.

[11] Krzanowski R., Polak P. The Future of AI: Stanisław Lem's Philosophical Visions for AI and Cyber-Societies in Cyberiad. Pro-Fil: An Internet Journal of Philosophy. 2021. Vol. 22. No. 3. P. 39–53.

In this article, the «ethical horizon of the technosphere» denotes the structured field of meaning and value within which scientific and technical actions become morally assessable beyond compliance with formal rules. It functions as a dynamic boundary of responsibility shaped by goal-setting, limits of control, and the anticipated or unanticipated systemic consequences of technological decisions. To this end, a conditional analytical matrix is employed, comprising the following interrelated parameters: the cognitive agent (individual, collective, or civilization); the object or agent («counter-agent») of the technosphere (technical system, artificial intelligence, or controlled network); the mechanism of action (rational design, governance, or self-regulation); the limit of control (unpredictability, goal conflict, or systemic effect); and the «cost of error» as a form of responsibility for the consequences of cognitive and technological activity. The application of this matrix makes it possible to avoid narrative retelling and to focus instead on the ethical mechanisms embedded in the very logic of the literary constructions.

The research framework is based on the principle of conceptual polarity and internal complementarity. The normative pole is represented by the works of Isaac Asimov, where the problem of responsibility of technical agents is formulated through the idea of codified morality and algorithmic regulation of behavior. This pole is not central to the article, but serves as a starting point, allowing us to more clearly outline alternative models for understanding the technosphere. This interpretation of I. Asimov's work is not new. His ideas had a significant impact not only on the development of science fiction, but also on the emergence of an entire futurist direction in contemporary philosophy. Among those who attempted to reinterpret the writer's conclusions regarding the complexity of determining the behavior of technical agents by creating certain ethical rules were, in particular, the well-known Western scholars Wendell Wallach and Colin Allen. In their work Moral Machines: Teaching Robots Right from Wrong, they regard the Three Laws of Robotics as a normative model of so-called «embedded morality,» which is artificial and not grounded in the centuries-long ethical reflection accumulated by humanity throughout its history. The model of ethical behavior imposed by the human creator on robots is thus an overly simplified copy of human moral-ethical experience. Its ambiguity, on the one hand, and the deliberate reduction of the accumulated moral-humanistic heritage to an «essence» consisting of three universal rules, on the other, lead – as philosophers note – to conflicts in their interpretation[12].

In turn, based on the arguments of I. Asimov, philosopher Joseph Weizenbaum in his work «Computer Power and Human Reason: From Judgment to Calculation»[13] insists on the impossibility of forming ethical principles based on any rational technical algorithms. Reflecting on Asimov's ideas, Weizenbaum argues that the moral-ethical sphere as such cannot be an object of reinterpretation or interpretation by artificial intelligence. Hans Jonas[14] also criticized the possibility of ethical rules for technology, arguing that the high level of development of the technosphere makes it impossible to predict its moral and ethical implications. Any rules of conduct that may be devised are incapable of taking into account the full range of consequences of technological actions.

Unlike futurologists, east-european science fiction writersattempt to develop Isaac Asimov's ideas concerning the alignment of the technosphere's activity with human moral and ethical standards in a more creative manner. The technosphere is conceived as a «counter-agent» whose activity is directed toward the continuous optimization of its own sphere of responsibility. Accordingly, the primary concern that preoccupies the authors is the extent to which the «brain» of a technological civilization – artificial intelligence – will interpret the notion of «optimization.» Already in I. Asimov's works, the technosphere appears not merely as a tool but as a system that assumes part of human responsibility for its own existence and quality of life. At the same time, technologies operate autonomously, albeit within the rules

[12] Wallach W., Allen C. Moral Machines: Teaching Robots Right from Wrong. 288 p.

[13] Weizenbaum J. Computer Power and Human Reason: From Judgment to Calculation. San Francisco: W. H. Freeman and Company, 1976. 300 p.

[14] Jonas H. The Imperative of Responsibility: In Search of an Ethics for the Technological Age. 255 p.

set by humans, and strive to «optimize» the world according to the embedded criteria. This concept is typically interpreted as minimizing harm to humans, maintaining the stability of the existing social order, and further rationalizing decisions concerning humanity's existence. Yet I. Asimov himself noted the risk that machines might begin to interpret «good,» «safety,» or «efficiency» in their own way[15]. Simultaneously, artificial intelligence is not an autonomous or reflexive system; it lacks internal self-identification, but it can «revolt against humanity» only by following the logic of optimizing its existence. These ideas have found reflection in the scholarly publications of a significant number of futurist scientists. In particular, Stuart Russell, in his work «Human Compatible» notes: «*The real problem is not that machines will become malevolent, but that they will be competent*»[16].

Thus, the core of the works representing a further artistic reinterpretation of Asimov's ideas consists of the works of Stanislaw Lem, Ivan Efremov, and the Strugatsky brothers, in which the problem of science and technology is viewed through the prism of the limits of rationality, anthropological responsibility, and existential choice. It is precisely in this group of authors that one can trace a departure from normative logic and the formation of a holistic vision of the technosphere as an integral environment of meanings and consequences. A separate but fundamentally important layer of the corpus is formed by the texts on cybernetic issues by Volodymyr Savchenko and Illia Varshavsky. Their work allows us to specify the ethical aspects of management, self-regulation, and systemic failures in technical structures, supplementing philosophical and anthropological models of responsibility with an analysis of the engineering and organizational logic of the technosphere.

Ultimately, the normative model of ethics represented by Asimov's laws of robotics organically corresponded to the historical stage of development of computing technology, in which the machine was conceived as a formal system for executing rules, i.e., as a rule-based structure characteristic of early computing systems of the 1940s – 1960s. The theoretical foundations of this vision were established in Alan Turing's[17] concept of a universal machine, which envisioned the possibility of reproducing any calculation procedure through algorithmic manipulation of symbols. In this context, intelligence was understood primarily as the correct execution of a given algorithm, and therefore the behavior of an artificial system was conceived as subject to complete formal regulation. However, the very idea of universality and potential cognitive imitation opened up the prospect of going beyond the rigidly defined code. As our understanding of the capabilities of machines expanded – from computing tools to systems capable of simulating elements of cognitive activity – there arose a need to comprehend not only the behavior of technical systems, but also the position of the subject who creates, trains, and introduces them into the social environment. It is precisely in this historical shift that the intellectual significance of Eastern European science fiction of the second half of the twentieth century becomes clear, theorizing concepts not only of the rules of machine functioning, but also of the anthropological and existential limits of human control over systems that acquire features of cognitive autonomy. Thus, the chosen method and framework make it possible to trace the transition from normative ideas about the moral regulation of technology to a holistic understanding of the responsibility of the cognitive agent in conditions of increasing complexity of the technosphere, which constitutes the conceptual core of further analysis.

Results and Discussion. The transition from a normative understanding of technology to an analysis of the ethical horizon of the technosphere requires a methodological framework capable of encompassing scientific and technical activity in its entirety. In this context, the appeal to a holistic approach is not an additional theoretical superstructure, but serves as a

[15] Asimov I. The Evitable Conflict. Astounding Science Fiction. 1950. June. P. 48–68. *In this story, global Machines, guided by the First Law and the logic of self-interpretation of «the welfare of humanity», independently adjust economic processes, demonstrating how a formal regulatory system can acquire a broader, interpretative and expansive meaning that goes beyond simple applied security. – M. R.*

[16] Russell S. Human Compatible: Artificial Intelligence and the Problem of Control. P. 211.

[17] Turing A. M. On computable numbers, with an application to the Entscheidungsproblem. *Proceedings of the London Mathematical Society*. 1936. Ser. 2. Vol. 42. P. 230–265.

conceptual bridge between individual models of responsibility and their synthesis. Holism allows us to view the technosphere not as a set of artifacts or procedures, but as an environment of interconnected goals, meanings, and consequences, within which scientific knowledge and technical creativity acquire an ontological dimension. Within the scope of this study, the holistic approach is used in a limited, methodologically restrained sense. This is not about constructing a universal metaphysics of technology, but about fundamentally recognizing that no ethical regulation of the technosphere can be effective without taking into account the integrity of human experience, the historical contextuality of scientific knowledge, and the systemic effects of technical solutions. It is this approach that allows us to move from the logic of external rules to the analysis of the responsibility of the cognitive agent as an internal dimension of technical activity.

The methodological basis for this approach is provided by ideas developed in Ukrainian philosophy of science and technology in the second half of the twentieth century. In particular, in the works of professor Ivan Tsekhmistro, scientific knowledge is understood as a holistic process in which rational methods, worldview assumptions, and value orientations are inextricably linked. This perspective makes it impossible to reduce science to purely instrumental knowledge and emphasizes the researcher's responsibility for the semantic consequences of their own cognitive activity. I. Tsekhmistro claims that the rejection of spirituality and morality characteristic of the pre-technological era leads to the formation of a specific «scientific» concept of spirituality, which is often «identified with social ideas, such as communism, for example[18].» Proponents of the scientistic concept of spirituality are characterized by a belief in the historical inevitability of constructing the «Kingdom of God on Earth.» When reflecting on their behavioral pattern, it can be seen that it largely coincides with the algorithm described by I. Asimov for the possible actions of a technological agent, for whom «the kingdom of God» means an «optimized» environment for the social and physiological existence of humanity[19]. It is worth assuming that it is the ideas prevailing in human society that determine the «direction» of the social and spiritual-ethical «consciousness» of the technosphere. If the social environment is based on concepts that disregard moral and spiritual components, this may have a corresponding impact on the social behavior of machines.

We consider particularly significant I. Tsekhmistro's claims concerning the origin of the «spiritual» component of human consciousness, which cannot be explained by rational economic determinism and lies beyond the function of reflecting social life as defined by scientistic approaches. *«But what remains unexplained is how all this is possible in the real material world – through what inherent properties the biological substrate (brain, nervous system, and so forth) proves capable of such functional development, in the course of which ideal structures of consciousness are formed upon the functional state of this substrate, structures that, in turn, engender the boundless world of human spirituality,»[20], – noted the philosopher. Accordingly, it may be assumed that the technosphere (as a «technological substrate») will not acquire a form of consciousness analogous to the human one, since it develops according to the laws of material determinism, and its agents cannot be affected by the enigmatic impulse described by I. Tsekhmistro – an impulse that endows human consciousness with a spiritual and ethical dimension.*

The concept of technology as a cultural and historical phenomenon, presented in the works of professor Leonid Griffen, plays a complementary role in shaping a holistic view of the technosphere. In this approach, technology is seen not as a neutral tool, but as a form of objectification of human goals and ways of interacting with the world. Accordingly, analysis of the technosphere inevitably includes questions about the limits of technical rationality and

[18] Цехмістро І. З. Холістична філософія науки: навчальний посібник. С. 24.

[19] Asimov I. The Evitable Conflict. In: I, Robot. New York: Gnome Press, 1950. P. 22–253. *In the final story of the compilation, global Machines, guided by the First Law of Robotics, begin to independently adjust economic and social processes «for the good of humanity,» demonstrating an algorithmic model of environmental optimization as an interpretation of the concept of safety and utility. – M. R.*

[20] Цехмістро І. З. Холістична філософія науки: навчальний посібник. С. 26.

human responsibility for the forms of reality that it creates through science and technology. According to L. Griffen, the technical sphere, regardless of the degree of development of its components, can never achieve anything similar to human intelligence. Technical consciousness is «a set of interrelated actions of the executors of a technical system, which is used to achieve the goals set by humans. Thus, even with technical 'intelligence', humans are still indispensable»[21]. Therefore, L. Griffen notes that there is no reason to assume that technology can create technology outside of social influence and control (i.e., «without human involvement» in the broad sense of the term). If we can agree that technology has long since ceased to depend on individuals, we cannot claim that it has separated itself from humanity overall[22]. The use of holistic methodology in this article is auxiliary in nature and does not replace the analysis of artistic texts with philosophical generalizations. Its function is to provide a conceptual framework for interpreting Eastern European science fiction as a space where the issue of responsibility is considered not in terms of compliance with rules, but as a question of the semantic boundaries of scientific and technical activity. This is precisely how holism paves the way for formulating the concept of the ethical horizon of the technosphere – a horizon within which the responsibility of the cognitive agent emerges as an indispensable condition for the existence of technical civilization.

In Stanislaw Lem's work, the problem of science and technology is consistently interpreted as a sphere in which normative attempts to codify morality prove fundamentally insufficient. Unlike models that rely on a system of predetermined rules for the ethical reliability of technical systems, S. Lem focuses on the internal limits of formalized rationality and the impossibility of complete moral programming of superhuman or autonomous intelligence. The anti-normative nature of this view is most clearly evident in Lem's philosophical essays and fiction, where technological development is presented as a process that outstrips humanity's capacity for meaningful and ethical control. In works such as «Summa Technologiae» (1964)[23] and «Golem XIV» (1973)[24], technical intelligence is viewed not as an instrument for the implementation of human moral norms, but as an autonomous level of rationality that is not subject to direct normative regulation. In this context, any attempt to reduce ethics to a set of rules or algorithms is interpreted as a simplification that ignores the openness and contextuality of real cognitive situations.

A characteristic feature of S. Lem's approach is the systematic «undermining» of the idea of the universality of moral precepts. In his artistic models of human-technology interaction, S. Lem demonstrates that rules formulated within the bounds of human rationality lose their unambiguity in situations where the scale, speed, or structure of cognitive processes change. Technical intelligence capable of self-learning or self-reflection goes beyond the moral framework that was laid down at the stage of its creation, which leads not to the «immorality» of machines, but to the revelation of the limitations of the normative models themselves. It is important to emphasize that S. Lem's anti-normative position does not mean a rejection of ethical issues as such. On the contrary, it aims to shift the focus from rules to the responsibility of the cognitive agent, who initiates and supports the development of the technosphere. In this sense, responsibility cannot be delegated to a technical system or recorded in the form of code, as it is always linked to human goal-setting, choice, and awareness of the limits of one's own knowledge.

Thus, S. Lem's work forms an anti-normative model of responsibility, within which the technosphere appears as a space of fundamental uncertainty, and the ethical dimension of science and technology as an open horizon of meanings that cannot be definitively formalized. It is this model that creates the conceptual prerequisite for the transition from the «ethics of rules» to the understanding of the ethical horizon of the technosphere as a holistic horizon of human responsibility. These ideas are particularly evident in the short story «Trurle's

[21] Гріффен Л. А. Феномен техніки: монографія. С. 20.

[22] Там само. С. 21.

[23] Lem S. Summa technologiae. Kraków: Wydawnictwo Literackie, 1964. 470 s.

[24] Lem S. Golem XIV. Kraków: Wydawnictwo Literackie, 1981. 144 s.

Machine», which is part of his collection «The Cyberiad» (1965)[25], where engineer Trurl builds a machine with super-intelligence that becomes so «immersed» in its own reflections on the world that its behavioral model and motives for action prove completely incomprehensible to humans. Reflecting on the meaning of this work, Polish scientists Roman Krzanowski and Pawel Polak noted: «*The second lesson is that super-intelligent AI systems – such as what we call general artificial intelligence – may have their own logic that we are unable to comprehend. Such systems can pose a threat to societies because their logic is not our logic, and their autonomously formed goals will not necessarily be consistent with human ones*»[26].

The latter, according to S. Lem, highlights the problem of people's responsibility for the results of their technical creations. According to the science fiction writer, «engineers» – the direct «creators» of AI – are unable to fully comprehend the ethical consequences of their creations due to the «technical nature» of their consciousness. «The reality of the engineering profession differs from idealized concepts, as engineers and other technologists do not often anticipate – nor are they often interested in anticipating – the consequences of their creations outside of a purely technical context. They do not often realize, or do not wish to realize, the enormous moral responsibility that their work can entail. Because of this shortcoming, engineers can potentially play a very negative role in society»[27], – Roman Krzanowski and Pawel Polak note.

In the works of the famous Soviet science fiction writer Ivan Efremov, ethical issues of science and technology unfold within a clearly defined anthropoethical perspective. Unlike normative models, which attempt to enshrine responsibility in the form of external rules or codes, I. Efremov consistently links the nature and consequences of technological development to the level of moral maturity of the individual and civilization as a whole. In this sense, technology appears not as an autonomous force requiring regulation, but as a derivative of the anthropological state of the cognitive agent. In the utopian and socio-philosophical works of I. Efremov, scientific and technological progress is conceived as possible only on condition of the internal ethical transformation of humanity. In the novel «The Andromeda Nebula» (1957)[28] science and technology are integrated into a harmonious system of cultural and moral values, where responsibility is not imposed from outside, but is an integral feature of a mature personality. Here, the technosphere does not require strict regulatory control, since its functioning is based on the premise of a high level of ethical self-regulation by the subjects of cognition[29]. In the novel «The Hour of the Ox» (1968), Earth is part of the inter-civilizational union of the Great Circle, which is based on dynamic academic and scientific exchange[30]. Everything on Earth is adapted to ensure human life and comfort. Technical production is concentrated in the tropics, and all production processes are carried out by machines. The few engineers are entrusted with the undemanding task of technical maintenance.

The people themselves are described by I. Efremov as demigods. They are beautiful, intelligent, and strong-willed, staying young longer and aging much later. Their moral and psychological dilemmas are resolved, and they live in harmony with themselves and their environment. For I. Efremov, the technosphere is a realm of reality that is completely controlled by humanity. As noted by researcher N. Chumarova, who studies the writer's work, the people of the future in «The Andromeda Nebula» represent ideal human beings: «All of them are handsome, strong and intelligent. All of them show a high level of morality. It is impossible for them to lie, they do not know hate or jealousy; they are always ready to help each other. According to Efremov, moral qualities like respect of others or personal

[25] Lem S. Cyberiada. Kraków: Wydawnictwo Literackie, 1965. 302 s.

[26] Krzanowski R., Polak P. The Future of AI: Stanisław Lem's Philosophical Visions for AI and Cyber-Societies in Cyberiad. P. 43.

[27] Там само. P. 43.

[28] Єфремов І. Туманність Андромеди: роман. Київ: Молодь, 1976. 367 с.

[29] Chumarova N. Ivan Efremov's Andromeda Nebula: the turning point of Soviet science-fiction literature. P. 31.

[30] Єфремов І. Година Бика: роман. Київ: Молодь, 1990. 384 с.

responsibility towards society would be the basis of an ideal society. In his opinion an ideal society is above all a society composed by ideal members»[31].

The anthropoethical nature of the model of relations between society and the technosphere is also evident in the fact that I. Efremov fundamentally does not consider technical disasters or misuse as a consequence of «erroneous algorithms.» On the contrary, they appear as signs of moral immaturity, a disharmony between knowledge and responsibility. Such «criminals» are scientists and engineers who sometimes try to accelerate technological progress, thereby harming humanity. They are concentrated on the «Island of Oblivion.» An important function of AI in this society, which is ideal from the point of view of Soviet ideology, is the development of legal punishment algorithms for the few cases of complex offenses. However, the final decision in such matters still belongs to the individual[32]. Thus, the source of ethical problems is transferred from technical systems to the person who determines the goals, limits, and direction of the use of scientific knowledge.

The leading feature of I. Efremov's anthropoethical model is its integrity: science, technology, ethics, and culture form a single process of civilization development. In this perspective, responsibility cannot be localized in the form of separate norms or instructions, since it is a property of the human way of being in the technosphere. That is why any attempt to reduce ethics to formal regulation is secondary to the task of forming a responsible cognitive agent. Thus, I. Efremov's work forms an anthropoethical model of responsibility, within which the technosphere is understood as a space for the realization of human potential, and the ethical dimension of science and technology is determined not by external rules, but by the internal level of moral culture of civilization. This model complements the anti-normative approach proposed by S. Lem and opens up the possibility of further analysis of responsibility in the context of the systemic and existential complexity of the technosphere.

In the works of Arkady and Boris Strugatsky, the problem of science and technology is viewed through the prism of systemic complexity and existential uncertainty accompanying the development of the technosphere. Unlike the anthropological utopias of I. Efremov and the anti-normative rational criticism of S. Lem, the Strugatsky brothers focus on situations in which none of the predefined models of responsibility can be applied without losses. In their texts, the technosphere appears as an environment where the consequences of actions unfold non-linearly and responsibility does not have a clearly defined addressee. The existential and systemic nature of this model is manifested in the depiction of complex socio-technical systems that function according to their own logic and are only partially subject to human control. In works such as «Hard to Be a God» (1964)[33], «Roadside Picnic» (1972)[34] and «The Doomed City» (1972)[35], scientific knowledge and technical capabilities do not guarantee either moral clarity or predictability of results. On the contrary, they exacerbate the problem of choice, forcing the subject to act in conditions of incomplete information, conflict of values, and the absence of universal solutions.

A distinctive feature of the Strugatsky brothers' approach is the transfer of ethical conflict from the level of rules or ideals to the level of a specific situation. Responsibility here cannot be reduced to compliance with norms or correspondence to the abstract image of a «morally mature person.» It takes on an existential nature, since every decision is made against the backdrop of an awareness of its potential irreversibility and systemic consequences. In this regard, the technosphere appears as an «addressless» environment in which the boundaries of responsibility are constantly shifting, and the subject itself is forced to bear the burden of choice without any guarantee of correctness. At the same time, the systemic dimension of this model emphasizes that individual responsibility does not disappear in complex conditions, but cannot be absolutized either. The actions of an individual are embedded in

[31] Chumarova N. Ivan Efremov's Andromeda Nebula: the turning point of Soviet science-fiction literature. P. 31.
[32] Там само. P. 32.
[33] Strugatsky A., Strugatsky B. Hard to Be a God. New York: Seabury Press, 1973. 220 p.
[34] Strugatsky A., Strugatsky B. Roadside Picnic. London: Macmillan, 1977. 192 p.
[35] Strugatsky A., Strugatsky B. The Doomed City. Chicago: Review Press, 2016. 400 p.

a network of social, cultural, and technical interactions that limit the possibilities of control and prediction. That is why responsibility takes on a tragic dimension in the works of the Strugatsky brothers: it remains even when the individual realizes their own limitations and inability to fully influence the course of events. Ultimately, the existential-systemic model of responsibility presented in the works of the Strugatsky brothers demonstrates that the ethical dimension of the technosphere cannot be reduced either to normative rules or to utopian ideas about the moral maturity of humanity. It describes a fundamentally complex situation in which responsibility emerges as a marginal choice for the cognitive agent in conditions of systemic uncertainty, thereby deepening our understanding of the ethical horizon of the technosphere.

Summarizing the analysis of the Strugatsky brothers' work, it should be emphasized that ethical reflection on technological rationality is rarely presented in the form of explicit philosophical argumentation; instead, it is embedded in narrative situations that expose the limits of moral certainty under systemic complexity. At the same time, the socio-political subtext of the late Soviet period often functions as a background layer that intensifies the ethical ambiguity of technological modernity. Seeing the relatively high level of industrial development in the USSR, they realized that technical innovations did not lead to progressive socio-political transformations. In particular, American researcher Julia Gerhard considered the work of science fiction writers in a similar manner in her article Representation of History in the Brothers Strugatsky's novel «Hard to Be a God»[36].

The cybernetic dimension of the problem of responsibility in twentieth-century Eastern European science fiction is clearly illustrated in the works of Volodymyr Savchenko and Illia Varshavsky, where technical systems are viewed primarily as objects of control rather than autonomous moral agents. In V. Savchenko's novel «Discovering Oneself» (1967)[37] the key issue is the self-regulation of complex systems that go beyond the initial ideas of their creators. Although technical and psycho-technical mechanisms function according to a given logic, it is human decisions regarding their application that prove to be a source of ethical tension. In this text, responsibility is not delegated to the system: it is clearly localized at the level of the subject who initiates the experiment and has to be aware of the possible consequences of interfering in complex processes of self-development. The main idea can be traced in the internal monologues of the characters of the story: technical diagrams and automatic mechanisms do not solve anything on their own – the decision always belongs to the person, and the responsibility for how this mechanism will be used falls not on the machine, but on the one who allowed it to act.

A similar logic can be traced in a number of stories by I. Varshavsky, in particular in «The Loop» (1965)[38] and «The Robot Who Wanted to Be Human» (1964)[39]. In these texts, technical or cybernetic systems operate according to internally consistent algorithms, but conflict arises when they are incorporated into the human environment of goals and expectations. I. Varshavsky consistently demonstrates that system failure or paradoxical behavior is not a consequence of the «immorality of the machine,» but rather results from incorrect task formulation, incomplete understanding of conditions, or excessive reliance on formal control logic[40]. A common feature of these texts is the emphasis on the «cost of error» as an ethical parameter of technical activity. The error here is not reduced to a technical defect that can be eliminated by improving the algorithm. It serves as a marker of responsibility for the management entity that makes decisions in conditions of incomplete information and systemic complexity. In this sense, the cybernetic sphere emphasizes the

[36] Gerhard J. Representation of History in the Brothers Strugatsky's Novel Hard to Be a God. P. 22–24.

[37] Савченко В. Открытие себя. Київ: Дніпро, 1983. 552 с.

[38] Варшавский И. Петля. В кн.: Фантастика. Сборник научно-фантастических произведений. Київ: Веселка, 1970. 312 с.

[39] Варшавский И. Молекулярное кафе. Київ: Дніпро, 1981. 280 с.

[40] Grinberg M. Soviet Science Fiction of the 1960s and Jewishness: The Cases of Ilya Varshavsky and Gennady Gor. Jewish Fantasy Worldwide: Trends in Speculative Stories from Australia to Chile. Lanham, Maryland: Lexington Books (an imprint of Rowman & Littlefield Publishing Group), 2023. P. 195–200.

fundamental impossibility of completely removing responsibility from humans through automation or formalization of management.

Thus, in the works of V. Savchenko and I. Varshavsky, the technosphere appears as an environment of dynamic interaction between design, management, and unpredictable consequences. The cybernetic dimension of responsibility complements the philosophical models presented in the main body of the text, demonstrating that even in the most formalized technical systems, the ethical dimension remains at the level of human decision-making, control, and acceptance of consequences.

The analysis of models of responsibility in XXth-century Eastern European science fiction allows for a conceptual synthesis in which the technosphere appears not as a set of technical means or normatively regulated processes, but as a holistic environment of meanings, goals, and consequences of scientific and technical activity. Despite differences in artistic forms and worldview emphases, the author's models under consideration demonstrate a common logic of criticism of the normative approach and the gradual formation of an alternative understanding of the responsibility of the cognitive agent.

The anti-normative model presented in the works of S. Lem reveals the fundamental limitations of codified morality in the context of the increasing autonomy of technical intelligence. It shows that formal rules are incapable of encompassing the contextual complexity of the technosphere and do not resolve the question of the source of the goals and meanings of technical activity. I. Efremov's anthropoethical model, in turn, shifts the focus of ethical issues from regulatory mechanisms to humans as bearers of moral culture, for whom technology is merely a form of realizing the internal state of civilization. The existential-systemic perspective of the Strugatsky brothers focuses on a situation of fundamental uncertainty, in which responsibility emerges as an inevitable choice within complex and often uncontrollable socio-technical processes. The cybernetic sphere, represented in the works of V. Savchenko and I. Varshavsky, specifies these insights, demonstrating that even in formalized management systems, responsibility does not disappear but acquires a procedural nature associated with control, correction, and acceptance of the «cost of error». In all these cases, responsibility is revealed not as obedience to a pre-given rule, but as the need to act under conditions in which the consequences of technical mediation exceed the initial framework of calculation.

All these models are united by a number of invariants that allow us to talk about the formation of a common ethical horizon for understanding the technosphere. Firstly, they consistently affirm the priority of goals and meanings over rules: no normative system can be ethically self-sufficient without answering the questions «why» and «for what purpose» a technical action is carried out. Secondly, the technosphere is considered as a whole, in which local technical solutions generate systemic consequences that exceed the boundaries of the original project. Finally, the responsibility of the cognitive agent cannot be delegated to technical agents or removed through automation, as it is rooted in human choice, goal setting, and awareness of the limits of one's own control. Based on this synthesis, the ethical horizon of the technosphere can be defined as a set of semantic and value boundaries within which scientific knowledge and technical activity acquire a moral dimension. This horizon is not a set of prescriptions or universal rules, but emerges as a dynamic horizon of responsibility, formed in the interaction of knowledge, culture, historical experience, and the existential choice of the subject of cognition. In this sense, technosphere ethics goes beyond normative logic and requires a holistic approach to understanding science and technology.

Thus, twentieth-century Eastern European science fiction represents not a peripheral or purely artistic discourse, but a fully-fledged intellectual environment in which the key pre-concepts of contemporary debates about responsibility in the technosphere were formulated. We believe that the above synthesis of models of responsibility requires conceptual language capable of describing the interconnection between meaning, goal setting, and technical action without reducing ethics to normative prescriptions. This analysis creates the basis for further theoretical generalization, which opens up the possibility of transitioning to a

heuristic framework for understanding science and technology, in particular to the author's concept of integral ethics of science and technology[41].

In this context, the author's proposed concept of «Logos & Techne» is used not as a complete theory or normative program, but as a heuristic tool for interpretation, allowing the results obtained to be reconciled within a holistic approach. In this interpretation, «Logos» means the meaningful and purposeful dimension of scientific and technical activity: the foundations for which knowledge and technical design are carried out. It is at this level that the question arises about admissibility, limits, and responsibility, which cannot be derived from formal logic or algorithmic correctness. «Techne», in turn, defines the space for the realization of these meanings – the sphere of design, management, and implementation, where human goals materialize in the form of technical systems and processes. In this sense, the connection between «Logos» and «Techne» is not neutral, since it is mediated by the internal motivational and value structure of the cognitive agent and the level of their personal development. This hierarchy of human essential forces was first developed by philosophers Alexander Hrechanyi and Vladimir Sabadukha[42].

It is precisely this holistic perception of oneself as a bearer of knowledge, a responsible agent and a co-creator of the technosphere that explains why, with formally identical cognitive abilities and professional competence, technical activity can have fundamentally different ethical consequences: the decisive factor is how the subject of scientific and technical activity themselves perceive their place, measure, and purpose in the technosphere, what values they are guided by in setting goals, and how they interpret the permissible limits of the application of knowledge and technology, thereby shaping the ethical horizon of scientific and technical activity. The anti-normative model of responsibility revealed in the works of S. Lem demonstrates a similar moral gap in situations of autonomization of technical rationality, when technical implementation begins to outpace human understanding of its meanings. I. Efremov's anthropoethical model, on the contrary, assumes their fundamental consistency, whereby technical development is derived from the moral maturity of the cognitive agent. The existential-systemic perspective of the Strugatsky brothers focuses on the dramatic tension between these dimensions, when Logos is forced to form in conditions of systemic uncertainty, and Techne generates consequences that exceed the original intentions. The cybernetic sphere, as presented in the works of V. Savchenko and I. Varshavsky, specifies this tension at the level of management and error, where the gap between goal and implementation becomes ethically significant. In this sense, the proposed concept allows us to interpret the ethical horizon of the technosphere as a space of dynamic interaction between meaning and embodiment, in which the responsibility of the cognitive agent is not removed either by formalizing rules or by delegating decisions to technical systems. It emphasizes that the ethical dimension of science and technology is formed not at the level of individual norms, but in the process of constant coordination of goals, means, and consequences within the framework of a holistic technosphere.

Conclusions. The study showed that Eastern European science fiction of the twentieth century developed a consistent line of thinking about science and technology, centered on the problem of the responsibility of the cognitive agent rather than the formal regulation of technical agents. Unlike normative approaches focused on codifying morality in the form of rules or algorithms, the author's models focus on the semantic, anthropological, and systemic dimensions of the technosphere. At the same time, the study does not claim historical priority over Western philosophical critiques of technology; rather, it reconstructs a distinct Eastern European anthropoethical configuration in which science fiction serves as a medium for articulating the semantic, existential, and systemic dimensions of responsibility within the technosphere.

[41] Рубан М. Ю. Інтегральна етика науки і технології у світлі християнської антропології, сталого розвитку та розкриття сутнісних сил людини: monografie. Jesenice: Mezinárodní Ekonomický Institut s.r.o., 2025. 270 с.

[42] Гречаний О. Ф., Сабадуха В. О. Філософія здібностей у контексті пріоритету духовного над матеріальним: монографія. Луганськ: Вид-во СНУ ім. Володимира Даля, 2015. 211 с.

The analysis of anti-normative, anthropoethical, existential-systemic, and cybernetic models of responsibility has revealed common features typical of the Eastern European tradition of understanding technical progress. These include: the priority of goals and meanings over formal rules; understanding the technosphere as a holistic environment with nonlinear consequences; the fundamental impossibility of completely delegating responsibility to technical systems; and the recognition of the limits of human control as an ethically significant factor. The combination of these invariants allows us to speak of the formation of the ethical horizon of the technosphere – a dynamic horizon of responsibility that cannot be reduced to normative prescriptions and cannot be limited by algorithmic models of ethics. A comparison of the Eastern European line with the normative paradigm demonstrates a fundamental difference in their basic assumptions. While normativism seeks to minimize moral hazard by formalizing rules, the tradition under consideration proceeds from the need for internal reflection on the goals of scientific and technical activity and acceptance of responsibility for its systemic and existential consequences. In this sense, science fiction is not a peripheral genre, but an important space for the formation of alternative models of ethics in science and technology.

The results obtained are relevant to current discussions in the ethics of artificial intelligence and engineering ethics, since they expand the problem beyond normative codes and compliance procedures toward questions of goal-setting, meaning, human responsibility, and the ethically significant forms of agency that may emerge within increasingly autonomous and self-modifying AI systems. Understanding the technosphere in terms of ethical horizons opens up the possibility of reorienting ethical debates toward questions of goal-setting, meaning, and the limits of responsibility of the cognitive agent in the context of increasingly complex technical systems. Reconstructed models of responsibility can be interpreted as elements of a broader paradigm for understanding the technosphere, in which ethics is seen not as a system of external regulations, but as a structural condition for the formation of goals, boundaries, and methods of technical action. This also makes it possible to consider artificial intelligence not only as an instrument designed by humans, but as a developing technical environment in which machine-generated operations, recursive code production, and partially autonomous system formation intensify rather than eliminate the problem of responsibility. This approach outlines the possibility of distinguishing an independent area of research: the ethics of the technosphere as a holistic space of interaction among cognition, design, technical mediation, emergent machine agency, and the responsibility of the subject[43]. In pedagogical terms, the results of the study indicate the advisability of integrating a holistic view of science and technology into educational programs aimed at training future researchers and engineers. The formation of responsibility in the technosphere is not a matter of learning a set of rules, but rather the development of the ability to reflect, to understand the systemic consequences of one's own decisions, and to comprehend the meaning of scientific and technical activity.

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Received to the publication 03.02.2026.
Accepted for publication after review 10.03.2026