Russian Journal of Astrophysical Research. Series A

Issued since 2015

E-ISSN: 2413-7499
2024. 10(1). Issued once a year

Journal is indexed by: **CrossRef, MIAR, OAJI, Russian Science Citation Index**

Postal Address: 1717 N Street NW, Suite 1, Washington, District of Columbia, USA 20036

Website: https://rjar.cherkasgu.press
E-mail: office@cherkasgu.press

Founder and Editor: Cherkas Global University

Release date 22.03.2024
Format 21 × 29,7/4.

Headset Georgia.

Order № RJAP-10.

Russian Journal of Astrophysical Research. Series A

2024

Is. **1**

CONTENTS

Articles

Published in the USA
Russian Journal of Astrophysical Research. Series A
Issued since 2013.
E-ISSN: 2413-7499
2024. 10(1): 3-8

DOI: 10.13187/rjar.2024.1.3
https://rjar.cherkasgu.press

Articles

Corporate Governance Space Vehicle

Sergey V. Bronnikov [a], [*]

[a] Scientific Secretary of the 9th Branch of the Russian Academy of Cosmonautics named after K.E. Tsiolkovsky, PJSC Rocket and Space Corporation Energia named after S.P. Korolev, Korolev, Moscow region, Russian Federation

Abstract

The article explores technologies for corporate management of spacecraft. It includes their ground training in flight control and the accumulation of control experience. The difference between corporate and collegial management is shown. Three types of corporate governance are described. Corporate spacecraft management is treated as an integrated technology that includes organizational, technological and cognitive components. This technology requires the use of space geoinformatics methods. Corporate management of spacecraft is organizational and technical. It introduces an additional management cycle: balancing or coordination of decisions. The cognitive factor is an important and necessary element of spacecraft control. Corporate management of spacecraft requires an additional management cycle – balancing. Another additional cycle of corporate governance is the management of spacecraft complementarity. These two additional cycles increase management time but are necessary components of corporate governance. Examples of corporate governance in land-based mobile objects are given. The connection between subsidiary management and corporate management of moving objects is shown. Socially sustainable corporate governance is described. The article describes the content and principles of corporate governance. A system model of corporate governance principles is given. The system components of corporate governance are described. Corporate spacecraft management is a new management and space technology. Spacecraft management can only be corporate, since this is the only way to reduce management complexity.

Keywords: space research, management, corporate governance, spacecraft, space geoinformatics.

1. Introduction

The control of spacecraft is characterized by an increase in the complexity of control situations and an increase in the control mechanism. It is necessary to take into account the factors of situational complexity and managerial complexity. Complexity is one of the components of big data (Levin, Tsvetkov, 2017). It can be argued that modern spacecraft control is associated with the need to solve the problem of "big data". The problem of the complexity of transport management and mobile objects are currently being solved through the use of intelligent transport systems

[*] Corresponding author
E-mail addresses: sbronnik@mail.ru (S.V. Bronnikov)

(Tsvetkov, Rosenberg, 2012), transport cyber-physical systems and the use of group control methods (Bronnikov, 2022). Logistics systems are used to manage flows.

Spacecraft control (CSCR) is a special type of control that does not occur in terrestrial conditions. CSCR can be thought of as a system and technology. CSCR as a system is COTS, which includes GIS. The latter is due to the fact thatgeoinformation technologies and GIS are a tool for decision support (Tsvetkov, 2001). In addition, CSCR is related to spatial management. Spatial management is solved using geoinformatics methods. CSCR as a technology is an integrated technology that includes organizational, technological and cognitive components. The cognitive components of management are a distinctive feature of the CSCR. CSCR technology requires the use of space geoinformatics methods (Bondur, Tsvetkov, 2015).

2. Results and discussion

Features of corporate governance

Corporate governance is a new concept. In the works (Considine, 1988, Petrin, 2019), intuitive definitions of corporate governance are given. A precise definition of corporate governance and the systematics of corporate governance are given in (Tsvetkov, 2023). Corporate governance is divided into collegial management of a complex object in a difficult situation and management of a group of objects.

Initially, corporate governance as collegial management was seen as a type of management by the top management of the campaign using a special unit called "headquarters". In the USSR, it was used by incompetent leaders to insure the decisions made. It was seen as a transition from one-man management to collegial management and, accordingly, to collegial responsibility. Corporate governance was initially used in campaigns to improve the sustainability of operations. Figure 1 shows the first version of corporate governance.

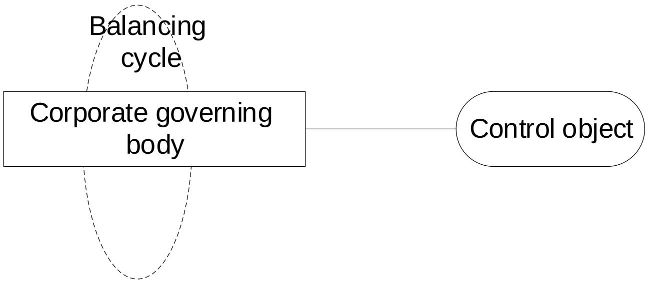

Fig. 1. Corporate governance option

In this embodiment, corporate governance is characterized by collegiality. This reduces subject errors and makes management more resilient. This is a positive characteristic of corporate governance. However, such management introduces an additional management cycle: balancing or reconciling decisions. The decisions of different experts may differ in details, but be coordinated in the main thing. For such coordination, additional technology is needed to coordinate or balance all participants in the corporate governance process. Figure 1 shows the "balancing cycle" (BC), which is necessary for the coordination of collegial decisions. This loop requires additional costs and is not required for centralized unified initial management. Coordination of actions in the management body (balancing) is a distinction between corporate governance. This is a lack of corporate governance. In the model in Figure 1 there is one management object and a corporate management body.

At the next stage, corporate governance was associated with the emergence of a multitude of management objects, the actions of which must be coordinated, since they solve a common strategic task. The second type of corporate governance uses the relationship "centralized management system – a set of management objects" (Figure 2). For example, in a city, a fleet of buses or taxis can be managed by a commercial company. All buses have clear routes and schedules. The presence of unforeseen circumstances (traffic jams, congestion, accidents) disrupts the traffic schedule and reduces passenger traffic. The goal of the campaign is to optimize traffic in the event of traffic disruption.

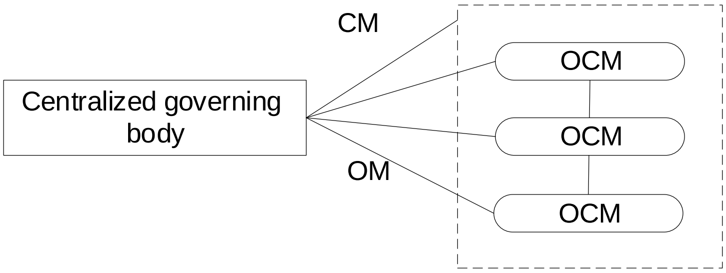

Fig. 2. The second option of corporate governance

Figure 2 shows this situation. There are many Enterprise Management Objects (OCMs) and there is a control center. Corporate governance technology uses two technologies: object management technology (OM) and complementarity management technology (CM) or object coordination technology. Coordination of actions of objects (balancing of actions) is a difference in corporate governance.

When managing a fleet of taxis, there is a more complicated situation. There are no clear schedules for this case. The taxi driver chooses the route according to the order. In fact, this is subsidiary management, if not for the presence of a control center. The main strategy is to load the machines. The control center (control room) performs the functions of regulation and optimization of orders. This is done manually, at the cognitive level. The more experience the dispatcher has, the more efficient the taxi network is.

A set of situations in this case sets a variety of conditions for movement and control. The key indicators of situations in this case are: the schedule of movement of many objects, the state of traffic flows, the volume of traffic flows. The dominant feature of management is the transportation of passengers and the complementarity of traffic.

The third type of corporate governance sets the relationship "corporate management system – a set of management objects". For example, any ministry has property and real estate located in different parts of the country. The Ministry of Transport carries out transportation within cities, between cities, on different modes of transport (multimodal transportation). The Ministry of Education has many universities that need to be managed in a coordinated manner, taking into account their property and human resources. The Ministry has many services, the internal actions of which need to be coordinated. The Ministry has many objects of management, the external actions of which must also be coordinated. Management in this case is multiple and multi-purpose. Figure 3 shows the corporate governance scheme for this option.

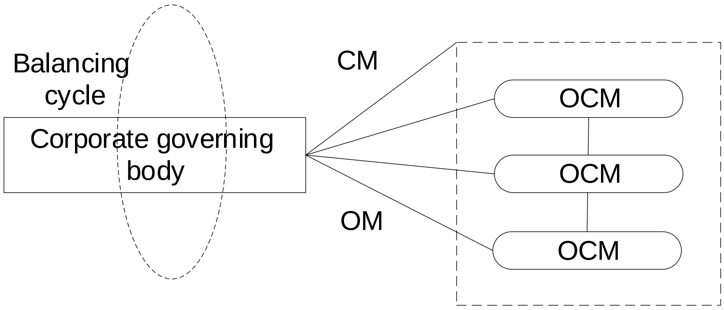

Fig. 3. The third scheme of corporate governance

In fact, there is a compilation of schemes in Figure 1 and schemes in Figure 2. But this is part of the differences, the main difference is in scale. Figures 1 and 2 describe the management of the campaign. Figure 3 describes sectoral corporate governance. This complicates both the balancing cycle (BC) and complementarity management (CM).

Thus, the difference between centralized management and corporate governance lies in the availability of technology for balancing management flows and the availability of additional technology for managing the complementarity of corporate objects.

With the accumulation of experience, the corporate governance structure of campaigns has become the basis for the transformation of public administration (Considine, 1998). Corporate governance in commercial firms used four basic principles: product format, instrumentalism, integration, and goal-orientedness. For public corporate governance, political and social factors must be taken into account. The concept of socially sustainable corporate governance has emerged «social responsibility of corporate management» (Coelho at al., 2003).

Corporate governance has been associated with such factors as: corporate social responsibility, corporate perimeter of the campaign, corporate informatization program, levels of corporate governance, corporate relations, corporate governance system, corporate data warehouse, corporate information system, corporate cyberspace, etc models of information situations in which the objects of corporate governance are located.

Content and principles of corporate governance

The number of principles of corporate governance (Corporate governance, CG) can be different. The well-known principles of governance can be combined into a model. System Model of Corporate Governance Principles (Corporative governance, 2023) (Principles of Corporate Governance, PCG) has the form

$$PCG=\langle Fa, Tr, RM, Res, Acc\rangle \quad (1)$$

In expression (1) Fa –Fairness, Tr – Transparency, RM – risk management, Res – Responsibility, Acc – Accountability.

Fairness. The Board of Directors has a duty to treat shareholders and communities fairly and with equal consideration.

Transparency. The board of directors should provide open information about various things and facts that affect the state of the campaign. These are: financial indicators, the presence of conflicts of interest, the presence of risks for shareholders and other parties.

Risk management. The Board of Directors must identify possible risks and ways to control and minimize them. For this purpose, agreed recommendations for risk management should be developed (Tsvetkov, 2014). The Board of Directors shall act in accordance with these recommendations. The Board of Directors shall inform all relevant parties of the existence and status of risks.

Responsibilities The Board of Directors is responsible for overseeing corporate affairs and management activities. He must be informed and support the work of the company. Responsibilities include the appointment of a CEO. The CEO must act in the best interests of the company and its investors.

Accountability. The board of directors should explain the company's goals and report on the results of its activities. The board of directors and management of the company are responsible for assessing the capabilities, potential and effectiveness of the company. The board of directors must communicate important issues to shareholders.

There are three main models of corporate governance: Anglo-American (AAM), continental (CM), Japanese model (JM). AAM can take many forms, depending on the dominant factor. For example, the shareholder model, the shareholder model and the political model. However, the shareholder model is the basic model in all forms

The shareholder model is designed in such a way that the board of directors and shareholders are in control of the situation. Stakeholders such as suppliers and employees, although recognized, have no control. The model allows shareholders to relinquish management if they are dissatisfied. This increases management efficiency.

The Board of Directors consists of insiders and independent members. The Chairman of the Board of Directors and the General Director may be one person. This model assumes that these duties are performed by two different people. U.S. regulators tend to support shareholders rather than boards.

The continental model is characterized by two groups: the supervisory board and the board. The board is made up of company insiders, such as its executives. The Supervisory Board is made up of third parties, such as shareholders and trade union representatives. Banks with stakes in the company could also have representatives on the supervisory board. The size of the supervisory board is determined by the legislation of the country. It cannot be changed by shareholders. National interests have a strong influence on this model of corporate governance.

The key players in the Japanese corporate governance model are banks, affiliates, major shareholders named Keiretsu (who can be invested in ordinary companies or have trading relationships), management, and government. Smaller, independent, individual shareholders have no role or voting rights. Key players carry out corporate governance. This model is focused on selected professionals and is the least transparent due to the concentration of power and the inequality of opportunities of different shareholders.

There are institutional criteria for assessing corporate governance. They are also called Positive management criteria (PMCs). They include the following factors:

PMC=<DP, MRM, SCB, RMM, MPCIR, OCBD, CSOC, RS, MRSC, EIEA> (2)

Expression (2) includes the following parameters:

- DP – Board Disclosure Practices
- MRM – Methodology of remuneration of managers
- SCB – system of checks and balances
- RMM – Risk management methodology
- MPCIR – Methodology and procedures for conflict of interest regulation
- OCBD- Operating conditions of the Board of Directors (their share of profits or conflict of interest)
- CSOC – Contractual and social obligations of the company
- RS – Relations with suppliers
- MRSC – Mechanism of reaction to shareholder complaints
- FIEA – Frequency of internal and external audits

Negative assessments of corporate governance include:

Companies that do not cooperate sufficiently with auditors or do not select auditors with the appropriate scale, which leads to the publication of false or non-compliant financial documents. Poor compensation packages for executives that don't create optimal incentives for corporate employees. Poorly structured boards of directors that make it too difficult for shareholders to displace inefficient incumbent operators.

Corrective and preventive action (CAPA) plays an important role in corporate and non-corporate governance (Westcott, 2005). This is a mechanism or rules for resolving internal and external conflict situations. A key concept in this mechanism is the identification of inconsistencies or undesirable situations. A non-conformity is: a complaint, a complaint, a failure of equipment, a decrease in quality, or a misinterpretation of the instructions. Corrective and preventive actions are developed by a team that includes quality assurance personnel and personnel involved in the actual monitoring of non-conformity. All of the principles discussed are applicable to the corporate governance of spacecraft.

3. Conclusion

Corporate management of spacecraft is organizational and technical. Corporate flight management is technical. The flight-only corporate board was described in (Bronnikov, 2022). This work dealt only with flight control and did not consider the organizational aspects of control and the methodology for controlling spacecraft. However, it did not cover all aspects of management. The proposed publication is a development and addition to the previously published publication. Corporate spacecraft management is a new management and space technology. Space Management devices can only be corporate, since this is the only way to reduce the complexity of management. Corporate spacecraft governance uses heuristics and meta-heuristics to analyze complex situations. This is the advantage of the method over intelligent control. A special feature of corporate spacecraft management is the use of information units. Corporate management of spacecraft, including organizational and cognitive factors. Corporate governance of spacecraft implicitly uses meta-heuristics methods. Space geoinformatics serves as the basis for decision support in the corporate management of spacecraft. A group of operators in the technology of corporate management of spacecraft is a self-organizing system. This increases the reliability of the corporate Management.

References

Bronnikov, 2022 – *Bronnikov, S.V.* (2022). Korporativnoe gruppovoe upravlenie poletom KA [Corporate group control of spacecraft flight]. *Slavyanskii forum*. 2(36): 60-67.

Levin, Tsvetkov, 2017 – *Levin, B.A., Tsvetkov, V.Ya.* (2017). Informatsionnye protsessy v prostranstve «bol'shikh dannykh» [Information processes in the space of “big data”]. *Mir transporta*. 15. 6(73): 20-30. [in Russian]

Tsvetkov, 2001 – *Tsvetkov, V.Ya.* (2001). Primenenie geoinformatsionnykh tekhnologii dlya podderzhki prinyatiya reshenii [Application of geographic information technologies to support decision making]. *Izvestiya vysshikh uchebnykh zavedenii.* Geodeziya i aerofotos"emka. 4: 128-138. [in Russian]

Tsvetkov, 2023 – *Tsvetkov, V.Ya.* (2023). Korporativnoe upravlenie: monografiya [Corporate governance: monograph]. Sofiya. 123 p. [in Russian]

Tsvetkov, Rozenberg, 2012 – *Tsvetkov, V.Ya., Rozenberg, I.N.* (2012). Intellektual'nye transportnye sistemy [Intelligent transport systems]. Saarbrücken, 297 p. [in Russian]

Bondur, Tsvetkov, 2015 – *Bondur, V.G., Tsvetkov, V.Ya.* (2015). New Scientific Direction of Space Geoinformatics *European Journal of Technology and Design*. 4(10): 118-126.

Coelho at al., 2003 – *Coelho, P.R.P., McClure, J.E., Spry, J.A.* (2003). The social responsibility of corporate management: A classical critique. *American journal of business*. 18(1): 15-24.

Considine, 1988 – *Considine, M.* (1988). The corporate management framework as administrative science: A critique. *Australian Journal of Public Administration*. 47(1): 4-18.

Considine, 1998 – *Considine, M.* (1998). The corporate management framework as administrative science: A critique. *Australian Journal of Public Administration*. 47(1): 4-18.

Corporative governance, 2023 – Corporative governance. 2023. [Electronic resource]. URL: https://www.investopedia.com/terms/c/corporategovernance.asp#:~%20:text=Corporate,%20governance (date of access: 01.02.2023).

Petrin, 2019 – *Petrin, M.* (2019). Corporate Management in the Age of AI. *Colum. Bus. L. Rev*. P. 965.

Tsvetkov, 2014 – *Tsvetkov, V.Ya.* (2014). Information Asymmetry as a Risk Factor. *European researcher*. 11-1(86): 1937-1943.

Westcott, 2005 – *Westcott, R.* (2005). Corrective vs. preventive action. *Quality Progress*. – 38(3): 104.

Published in the USA
Russian Journal of Astrophysical Research. Series A
Issued since 2013.
E-ISSN: 2413-7499
2024. 10(1): 9-12

DOI: 10.13187/rjar.2024.1.9
https://rjar.cherkasgu.press

Instrumental Space Astronomy

Gospodinov Slaveyko Gospodinov [a, *]

[a] University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria

Abstract

The article explores instrumental space astronomy as a direction in space research. Instrumental space astronomy is closer to space geodesy and space geoinformatics than to astronomy. The trend of transformation of earth sciences into space sciences has been noted. The structure of instrumental space astronomy is shown. Instrumental space astronomy is a development of the direction of observational astronomy. However, observations are complemented by measurements and modeling. Instrumental space astronomy differs from classical astronomy in the use of spatial logic, geomonitoring and spatial modeling. Classical astronomy studies celestial objects from great distances. Instrumental space astronomy studies planets from short distances comparable to several planetary radii. Classical astronomy studies celestial objects from the surface of the earth using radio telescopes. Instrumental space astronomy explores planets from spacecraft. Classical astronomy examines celestial objects using angular measurements and navigational estimates. Instrumental space astronomy explores planets using linear and angular measurements, models and simulations. Instrumental space astronomy studies objects using the methodological apparatus of space geoinformatics and space geodesy. Instrumental space astronomy provides tools for studying planets and therefore it is also close to comparative planetology.

Keywords: space research, space astronomy, instrumental space astronomy, space geoinformatics, space geodesy, geodetic astronomy.

1. Introduction

Astronomy is one of the oldest sciences. It arose from the practical needs of navigation and determining the exact time. Classical astronomy studies stars, planets of the solar system and their satellites, exoplanets, asteroids, comets, meteoroids, interplanetary matter, interstellar matter, pulsars, black holes, nebulae, galaxies and their clusters, quasars, and more (Surdin, 2021; Karttunen et al., 2007). The main general directions of classical astronomy are four sections (Surdin, 2021; Karttunen et al., 2007): 1. The study of the visible and actual positions of celestial bodies in space, the determination of their size and shape. 2. The study of the structure of celestial bodies, the study of the chemical composition and physical properties (density, temperature, etc.) of the substance in them. 3. Solving the problems of the origin and development of individual celestial bodies and the systems formed by them. 4. The study of the most general properties of the Universe, the construction of the theory of the observable part of the Universe – the Metagalaxy.

* Corresponding author
E-mail addresses: sgospodinov@mail.bg (G.S. Gospodinov)

2. Results and discussion

For classical astronomy, the term "distant" can be introduced. For instrumental space astronomy, the term "local" can be introduced. Instrumental space astronomy belongs to the first section. It deals with the study of the visible and actual sizes and shapes of celestial bodies, as well as their characteristics, volume and area. Classical astronomy focuses on terrestrial observations. Instrumental space astronomy is focused on observations from spacecraft. Instrumental space astronomy is closely related to a number of special sciences: geodetic astronomy (Gospodinov, 2018; Gospodinov, 2022), space geodesy (Oznamets, 2023), space geoinformatics (Bondur, Tsvetkov, 2015), computer science (Gospodinov, 2023) and applied informatics (Polyakov, Tsvetkov, 2002).

Instrumental space astronomy (Gospodinov, Tsvetkov, 2023) is close in methods to applied geoinformatics and applied informatics. Space research is aimed at studying the external environment in the form of near and far space. The modern peculiarity of space research is that it is based on methods and knowledge obtained in terrestrial conditions and in the course of the study of the planet Earth. Earth sciences make a significant contribution to the development of space research.

Figure 1 shows the trend of transformation of earth sciences into space sciences.

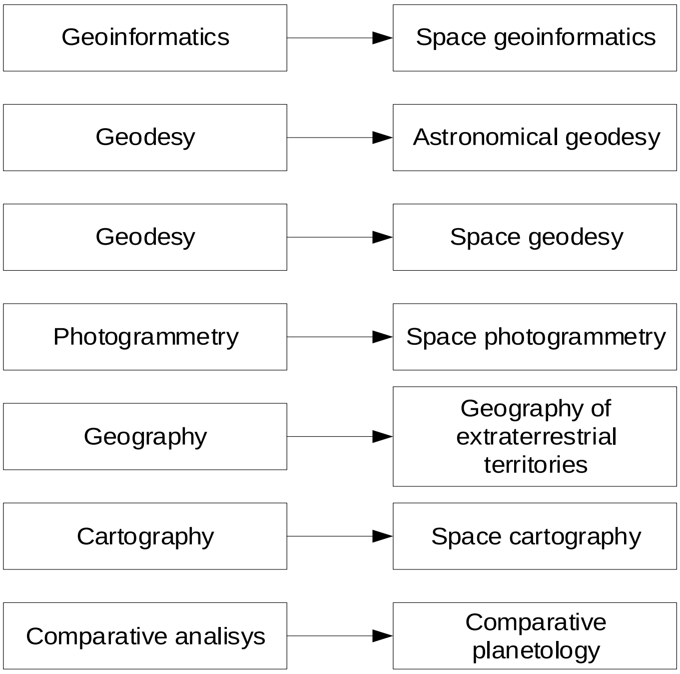

Fig. 1. Transformation of terrestrial sciences into space directions.

Modern space research and the construction of a picture of the world are associated with the use of "terrestrial" sciences of geoinformatics, geography, geodesy. Space geodesy, space geography (Savinykh i dr., 2009), space geology (Katz, Ryabukhin, 1984), geodetic astronomy exist and are used. Geoinformatics as a science that integrates the Earth sciences (Maksudova et al., 2000) also has every basis for the term space.

Earth sciences are the basis for research. The main object of comparison in space research is the Earth. As a planet, it is better studied and all possible measurements can be made on it. The use of Earth exploration data as an analogue for comparison with other bodies is most common in such sciences as comparative planetology, planetary geology, geomorphology and atmospheric sciences. Hence there was a tendency to transfer the methods of Earth sciences (geoinformatics, geodesy, geodynamics, photogrammetry, cartography) for use in space research. Space research is an important tool for studying the world around us (Stepanov, Aksenova, 2014). Space research is an important component in building a picture of the world (Savinykh, 2015; Tsvetkov, 2014a; Tsvetkov, 2014b).

Instrumental space astronomy arose on the basis of the integration of a number of sciences into this science. Figure 2 shows the components of the integration of instrumental space astronomy.

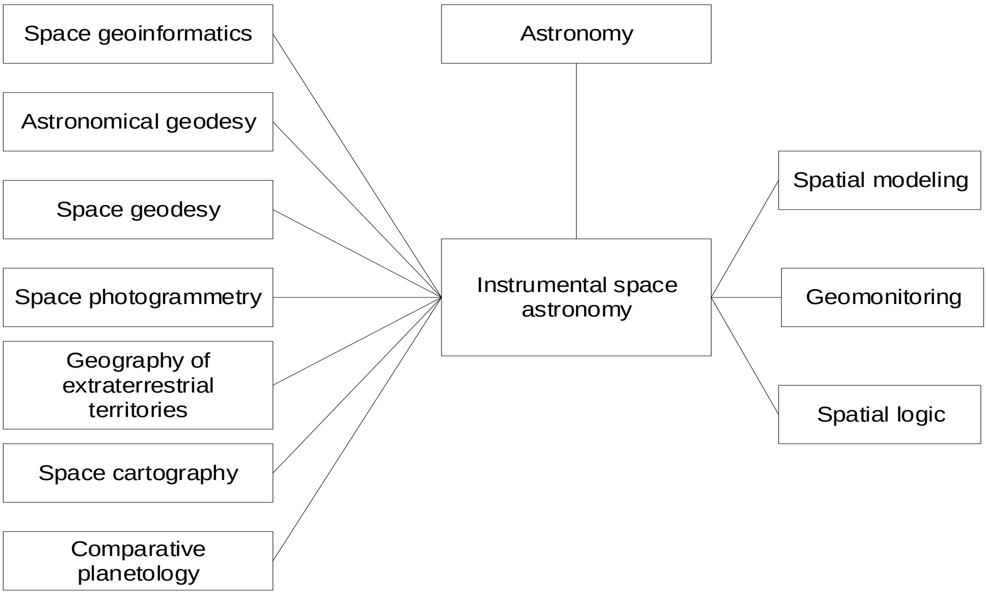

Fig. 2. Components of integration of instrumental space astronomy

In Figure 2 the difference between instrumental space astronomy and astronomy can be seen. It is expressed in the application of spatial logic and spatial modeling. In instrumental space astronomy, geomonitoring is used as a kind of comic monitoring.

Instrumental space astronomy is close to geoinformatics and space geoinformatics in terms of concepts and modeling methods

Geoinformatics and space geoinformatics, as instrumental space astronomy, is a tool for studying the world around us and building a picture of the world (Butko, 2017). This brings space geoinformatics and instrumental space astronomy closer together. Space research is aimed at obtaining new knowledge and finding tacit knowledge (Tsvetkov, 2014). Space geoinformatics and instrumental space astronomy explore tacit knowledge. Cosmic geoinformatics acquires new knowledge, spatial knowledge (Tsvetkov, 2015) and geoknowledge. Instrumental space astronomy does the same.

It also brings space geoinformatics and instrumental space astronomy closer together. There are a number of works in the field of geodesy, in which it is proved that geodesy is the science of space. This gives reason to believe that instrumental space astronomy can also be considered as a science of space. The specialization of astronomy in the instrumental study of outer space leads to instrumental space astronomy

This term has not yet found wide application. Therefore, in general, we can talk about instrumental space astronomy as a tool for space exploration. Instrumental space astronomy requires the introduction of new methods of analysis, due to new tasks and requirements. Instrumental space astronomy requires research and development of new analytical, algorithmic and technological methods. In contrast to space geodesy, space geography, geodetic astronomy, the peculiarity of instrumental space astronomy is an integrated approach to the study of outer space. This integrated approach is borrowed from space geoinformatics. Space geoinformatics provides model-level comparability and analysis. At the level of technology, instrumental space astronomy creates a tool for the exchange of methods of analysis and processing. At the level of cognition, instrumental space astronomy, a similar to astronomy and geoinformatics, contributes to the integration of sciences. This property is transferred to space astronomy and makes instrumental space astronomy a means of universal exploration of outer space.

3. Conclusion

Instrumental space astronomy is a new scientific direction. It aims to study planets from distances comparable to several radii of planets. Instrumental space astronomy complements classical astronomy. It is a development of its direction of observational astronomy. Observational astronomy is concerned with obtaining observational data about celestial bodies, which are then analyzed. Instrumental space astronomy not only obtains data, but also carries out logical and geometric constructions and obtains the real dimensions of the bodies under study. Instrumental space astronomy is not only an observation tool, but also a measurement tool, calculations and modeling.

References

Butko, 2017 – *Butko, E.Ya.* (2017). Geoinformatika kak metod postroeniya kartiny mira [Geoinformatics as a method for constructing a picture of the world]. *Slavyanskij forum*. 1(15): 34-41. [in Russian]

Gospodinov, Tsvetkov, 2023 – *Gospodinov, S.G., Tsvetkov, V.Ya*. (2023). Nekotorye teoreticheskie aspekty instrumental'nyh metodov kosmicheskoj astronomii [Some theoretical aspects of instrumental methods of space astronomy]. Sofiya. 92 p. [in Russian]

Gospodinov, 2023 – *Gospodinov, S.G.* (2023). Sovremennaya informatika [Modern computer science]. Saarbruken, 157 p. [in Russian]

Kac, Ryabuhin, 1984 – *Kac, Ya.G., Ryabuhin, A.G.* (1984). Kosmicheskaya geologiya [Space geology]. M.: Prosveshchenie. [in Russian]

Maksudova i dr., 2000 – *Maksudova, L.G., Savinyh, V.P., Tsvetkov, V.Ya*. (2000). Integraciya nauk ob okruzhayushchem mire v geoinformatike [Integration of sciences about the surrounding world in geoinformatics]. *Issledovanie Zemli iz kosmosa*. 1: 46-50. [in Russian]

Polyakov, Tsvetkov, 2002 – *Polyakov, A.A., Tsvetkov, V.Ya*. (2002). Prikladnaya informatika [Applied Informatics]. M.: YAnus-K, 392 p. [in Russian]

Savinyh, 2015 – *Savinyh, V.P.* (2015). Kosmicheskie issledovaniya kak sredstvo formirovaniya kartiny mira [Space research as a means of forming a picture of the world]. *Perspektivy nauki i obrazovaniya*. 1: 56-62. [in Russian]

Savinyh i dr., 2009 – *Savinyh, V.P., Smirnov, L.E., Shingareva, K.B.* (2009). Geografiya vnezemnyh territorij [Geography of extraterrestrial territories]. M.: Drofa. [in Russian]

Stepanov, Aksenova, 2014 – *Stepanov, A.N., Aksenova, A.O.* (2014). Esteticheskaya teleologiya kosmicheskih issledovanij [Aesthetic teleology of space research]. *Problemy sovremennoj nauki i obrazovaniya*. 12(30): 1.3. [in Russian]

Surdin, 2021 – *Surdin, V.G.* (2021). Astronomiya [Astronomy]. Moskva, MGU, 384 p. [in Russian]

Tsvetkov, 2014a – *Tsvetkov, V.Ya.* (2014). Informacionnoe opisanie kartiny mira [Information description of the picture of the world]. *Perspektivy nauki i obrazovaniya*. 5(11): 9-13. [in Russian]

Tsvetkov, 2014b – *Tsvetkov, V.Ya.* (2014). Informacionnye edinicy kak sredstvo postroeniya kartiny mira [Information units as a means of constructing a picture of the world]. *Mezhdunarodnyj zhurnal prikladnyh i fundamental'nyh issledovanij*.8(4): 36-40. [in Russian]

Tsvetkov, 2014c – *Tsvetkov, V.Ya.* (2014). Analiz neyavnogo znaniya [Analysis of tacit knowledge]. *Perspektivy nauki i obrazovaniya*. 1(7): 56-60. [in Russian]

Tsvetkov, 2015 – *Tsvetkov,* V.Ya. (2015). Formirovanie prostranstvennyh znanij: Monografiya [Formation of spatial knowledge: Monograph]. M.: MAKS Press, 68 p. [in Russian]

Bondur, Tsvetkov, 2015 – *Bondur, V.G., Tsvetkov, V.Ya.* (2015.). New Scientific Direction of Space Geoinformatics. *European Journal of Technology and Design*. 4(10): 118-126.

Gospodinov, 2018 – *Gospodinov, S.G.* (2018). The Development of Geodesic Astronomy. *Russian Journal of Astrophysical Research. Series A*. 4(1): 9-33.

Gospodinov, 2022 – *Gospodinov, S.G.* (2022). Evolution of geodetic astronomy. *Russian Journal of Astrophysical Research. Series A*. 8(1): 3-11.

Karttunen et al., 2007 – *Karttunen, H. et al.* (ed.). (2007). Fundamental astronomy. Berlin, Heidelberg: Springer Berlin Heidelberg.

Oznamets, 2023 – *Oznamets, V.V.* (2023). The Evolution of Space Geodesy. *Russian Journal of Astrophysical Research. Series A*. 9(1): 14-19.

Published in the USA
Russian Journal of Astrophysical Research. Series A
Issued since 2013.
E-ISSN: 2413-7499
2024. 10(1): 13-17

DOI: 10.13187/rjar.2024.1.13
https://rjar.cherkasgu.press

Systematics of Near-Earth Space

Stanislav A. Kudzh [a, *]

[a] Russian Technological University (RTU MIREA), Moscow, Russian Federation

Abstract

The article explores the content of near-Earth outer space. The presence of zones that create the heterogeneity of space is shown. The morphology and semantics of near-Earth space is investigated. Different approaches to estimating the boundaries of near-Earth space are described. The concept of "geocentric space" is introduced as a spherical model and a generalization of the near-Earth space. Geocentric space has floating boundaries and may include lunar space. The systematics of geocentric space up to the orbit of the Moon is given. The systematics of outer space zones is made on the basis of their distance from the center and the surface of the Earth. Eleven zones have been identified. Some zones are physical in nature, other zones are anthropogenic. The article introduces the concept of morphological and semantic modeling in space research. Morphological modeling differs from the parametric morphological analysis introduced by Zwicke. Morphological modeling in space research is proposed as a kind of geometric modeling associated with conformal transformations. A special case of morphological modeling is shown as a kind of cartographic transformations. Semantic modeling in space research is proposed as a method of parametric transformations and analysis of the similarity of models in terms of content. A graphical scheme of the systematics of near-Earth outer space is given. The features of the zones that create heterogeneity are described. The upper zone from the center of the Earth indicates the area of lunar attraction. In the proposed model, lunar space is not included in the region of near-Earth space.

Keywords: space research, near-Earth space, morphological modeling, semantic modeling, heterogeneity.

1. Introduction

Near-Earth space (NES) is associated with the geocentric model and refers to the part of spherical space relative to the Earth. The study of near-Earth space (Barmin et al., 2014), as well as the study of the Earth-Moon system (Savinych, 2022), shows that this space is heterogeneous and contains qualitatively different regions or zones. Near-Earth space is evaluated in different ways. A simple assessment includes the space between the orbit of the Earth and the Moon. This estimate sets a fixed boundary of the NES. There is no room for lunar space in this assessment. Lunar space has the same nature as near-Earth space, but has a smaller size. Near-Earth space will be considered an area that does not include lunar space. This means that the Moon's gravitational region does not enter the NES. This space is defined by (Bakulin et al., 1983) with a radius of 66,000 km centered in the center of the Moon. Since the time of Aristotle (1974), there has been another definition of the region between the Moon and the Earth – sublunary space. There is a

* Corresponding author
E-mail addresses: rektor@mirea.ru (S.A. Kudzh)

point of view that near-Earth space is a part of geocentric space mastered by man. This estimate gives a floating boundary and allows for the presence of lunar space. The use of the concept of geocentric space (GS) eliminates the contradiction between the definitions of NES and the presence of lunar space. Geocentric space has a fixed center in the barycenter of the Earth and a floating boundary given by a radius relative to that center. The boundary is determined by the task of the study. In a broad sense, GS includes NES. In special cases, GS may be part of the NES. For example, the space of satellite orbits or the space of space debris (Barmin et al., 2014b).

GS research technologies and methods use Earth science methods. The development of space research is characterized, on the one hand, by the emergence of a number of special sciences: space geodesy (Oznamets, Tsvetkov, 2019; Bertiger et al, 2020; Oznamets, 2023), geodetic astronomy (Gospodinov, 2022), space geoinformatics (Bondur, Tsvetkov, 2015a), space astronomy (Gospodinov, Tsvetkov, 2023) and other sciences. The development of space research, on the other hand, is characterized by an increase in the data collected and big data problem (Allam, Dhunny, 2019; Levin, Tsvetkov, 2017). The growth of GS data increases awareness of this field and reveals facts that allow us to consider NES as a heterogeneous structure (Wu et al., 2019). This article is devoted to this problem.

Morphology and semantics of cosmic information.

In space research, models of celestial bodies have morphology and semantics. Morphology in space research is associated with the shape of celestial bodies, the trajectory of the orbits of celestial ones, and the spatial relationships between celestial bodies. Carriers of morphological properties are mathematical and information models. The global model is the information field in space research. Space monitoring is the basis for obtaining information about outer space (Kudzh, 2022; Tsvetkov, 2023). Morphology is important in the formation of spatial knowledge.

You can introduce the concept of morphological models. Mathematical models and morphological models have the important property of universality. The property of the universality of mathematical models is that different processes of the reality of the world can be described by the same formula or structure. The property of the universality of morphological models is that different objects of space research can be described by the same form. For example, the Earth, the Moon, and many planets can be roughly described by a sphere. The orbits of the planets describe mathematical models of the second-order curve.

You can introduce the concept of morphological modeling. Morphological modeling is a simulation that changes shape and allows one shape to be transformed into another. For example, a sphere can be converted to an ellipsoid. In cartography, a spherical body is transformed into a cone, a cylinder, and a plane. This leads to the creation of maps of different cartographic projections: conical. Cylindrical, azimuthal. In space photogrammetry, panoramic images are converted into a different form or create maps of a certain projection from the images. The basis of morphological transformations are conformal transformations and information morphism. Structural modeling is a type of morphological modeling. The formation of the configuration of space is an example of morphological modeling. Geocentric space or the space of the solar system are morphological models. The heliocentric system is a morphological model.

The semantics of GS space exploration is closely related to morphology. The semantics of GS is expressed through the semantics of the objects of this space. Different parts of different planets have a common characteristic area. Area can be thought of as a semantic characteristic. Different areas have different configurations. The areas of different shapes can be equal or proportionate. The shapes of the plots are different. Shapes determine morphology. The area of the shape determines the semantics.

Semantics uses a parametric description. There is semantic modeling that explores the content. Semantic modeling uses special procedures. A typical semantic procedure is semantic division. Semantic division consists in dividing the parametric description of the GS model or objects into classes according to given classification criteria. Semantic division is carried out in the parameter space, without taking into account morphology. A characteristic technique of semantic division is the method of "separating hyperplane" (Anikin et al., 1980). It divides the parameter space into two classes. Other types of semantic division are oppositional (Tsvetkov, 2014) and dichotomous division.

An important procedure for semantic analysis is the comparison of content. An example of such a procedure is correlative (Tsvetkov, 2012) semantic analysis. Semantic correlative analysis should be distinguished from statistical correlation analysis. Semantic correlative analysis reveals a qualitative relationship between content. Correlation statistical analysis provides quantitative statistical estimates without taking into account a possible relationship

2. Results and discussion

Heterogeneity of near-Earth space.

Figure 1 shows the diagrams of the boundaries of different zones in the NES (GS). The dotted line indicates the areas of satellite orbits.

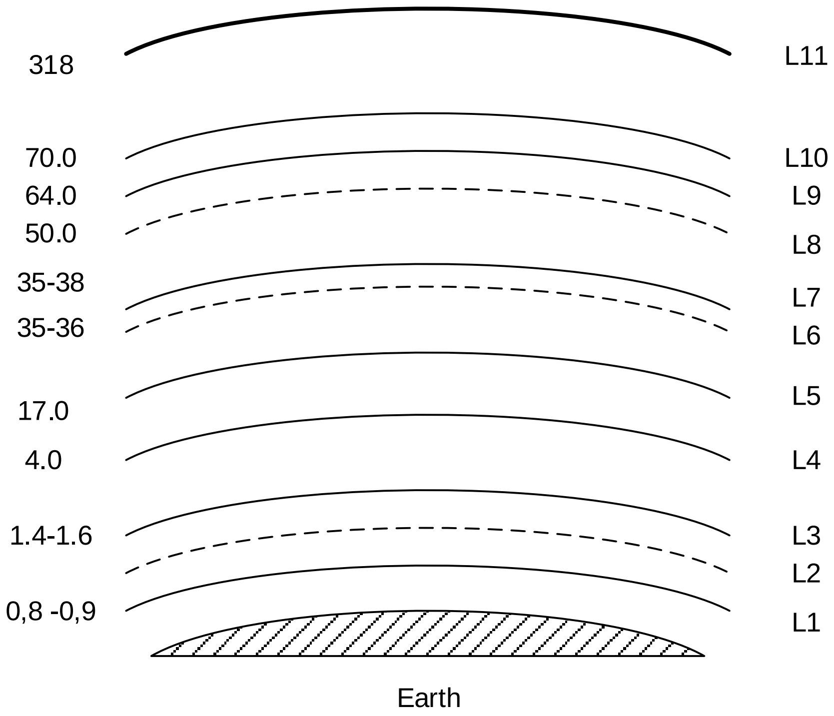

Fig. 1. Area boundaries in the NES

In Figure 1, the zone boundaries are indicated by the symbol L. Some areas may overlap. On the left, the heights from the Earth are shown in thousands of kilometers, on the right are the zone identifiers. The taxonomy of zones is given as they move away from the Earth and the earth's surface. Boundary designations have the following meanings:

L1 – denotes the first lower belt of space debris rings and corresponds to an altitude above the earth's surface of 800-900 km.

L2 – denotes the region of low satellite orbits and corresponds to an altitude above the earth's surface of 700-1500 km.

L3 – denotes the second lower belt of space debris rings and corresponds to an altitude above the earth's surface of 1400-1600 km.

Above are the radiation belts, which are toroid-shaped and form two areas.

L4 – denotes the inner radiation belt, consisting mainly of protons with an energy of tens of MeV and corresponds to an altitude above the earth's surface of about 4000 km.

L5 – denotes the outer radiation belt, consisting mainly of electrons with an energy of tens of keV and corresponds to an altitude above the earth's surface of approximately 17,000 km.

L6 – denotes the region of geostationary orbits and corresponds to an altitude above the earth's surface of 35,000-36,000 km.

L7 – denotes the upper belt of space debris rings and corresponds to an altitude above the earth's surface of 35,000-36,000 km.

Zones L 6 and L7 are almost identical, which is of interest for research.

L8 – denotes the region of high orbits and corresponds to an altitude above the earth's surface of 50,000 km.

L9 – denotes the area of the fourth and fifth libration points and corresponds to an altitude above the earth's surface of 64,000 km.

L10 – denotes the boundary of the Earth's magnetosphere and corresponds to an altitude above the earth's surface of 70,000 km

L11 denotes the actual boundary of the NES, beyond which the region of lunar attraction occurs and corresponds to a distance from the center of the Earth of approximately 318,000 km.

3. Conclusion

Near-Earth space is heterogeneous and contains different zones. The systematics of near-Earth space zones has not yet been carried out in a comprehensive manner. This is due to the significantly different physical nature of these zones and areas of use. It is possible to state a significant heterogeneity of near-Earth space. Heterogeneity is expressed in the presence of spatial areas or zones in near-Earth space. Some zones of near-Earth space are of a physical nature, others are anthropogenic. The systems approach gives reason to believe that these homogeneities are part of a general system that has not yet been investigated. The systematic approach gives reason to believe that the areas of near-Earth space are interconnected. But these connections have not yet been studied. The use of morphological and semantic modeling, according to the author, will help in the study of the heterogeneity of geocentric space. The basis for the study of the heterogeneity of near-Earth space remains space monitoring (Savinych, 2017). The systematics of the zones of outer space is made on the basis of their distance from the center and the surface of the Earth.

References

Allam, Dhunny, 2019 – *Allam, Z., Dhunny, Z.A.* (2019). On big data, artificial intelligence and smart cities. Cities. 89: 80-91.

Anikina i dr., 1980 – *Anikina, G.A., Polyakov, M.G., Romanov, L.N., Tsvetkov, V.Ya*. (1980). O vydelenii kontura izobrazheniya s pomoshch'yu lineinykh obuchaemykh modelei [On image contour extraction using linear learning models]. *Izvestiya akademii nauk SSSR*. Tekhnicheskaya kibernetika. 6: 36-43. [in Russian]

Aristotle, 1974 – *Aristotle* (1974). Ethics. P. 357.

Bakulin i dr., 1983 – *Bakulin. P.I., Kononovich. E.V., Moroz. V.I.* (1983). Kurs obshchei astronomii [Course of general astronomy.]. 5-e izd. M.: Nauka. P. 110. [in Russian]

Barmin et al., 2014b – *Barmin, I.V., Dunham, D.W., Kulagin, V.P., Savinykh, V.P., Tsvetkov, V.Ya.* (2014). Rings of Debris in Near_Earth Space. *Solar System Research*. 48(7):. 592-599. DOI: 10.1134/S0038094614070041

Barmin, et al., 2014a – *Barmin, I.V., Kulagin, V.P., Savinykh, V.P., Tsvetkov, V.Ya*. (2014). Near_Earth Space as an Object of Global Monitoring. *Solar System Research*. 48(7): 531-535.

Bertiger et al., 2020 – *Bertiger, W. et al.* (2020). GipsyX/RTGx, a new tool set for space geodetic operations and research. *Advances in space research*. 66(3): 469-489.

Bondur, Tsvetkov, 2015 – *Bondur, V.G., Tsvetkov, V.Ya*. (2015). New Scientific Direction of Space Geoinformatics. *European Journal of Technology and Design*. 4(10): 118-126.

Gospodinov, 2022 – *Gospodinov, S.G.* (2022). Evolution of geodetic astronomy. *Russian Journal of Astrophysical Research. Series A*. 8(1): 3-11.

Gospodinov, Tsvetkov, 2023 – *Gospodinov, S.G, Tsvetkov, V.Ya*. (2023). Nekotorye teoreticheskie aspekty instrumental'nykh metodov kosmicheskoi astronomii [Some theoretical aspects of instrumental methods of space astronomy]. Sofiya. Art Eternal Cinema. 92 p. [in Russian]

Kudzh, 2022 – *Kudzh, S.A.* (2022). Development of space monitoring. *Russian Journal of Astrophysical Research. Series A*. 8(1): 12-22.

Levin, Tsvetkov, 2017 – *Levin, B.A., Tsvetkov, V.Ya.* (2017). Informatsionnye protsessy v prostranstve «bol'shikh dannykh» [Information processes in the space of "big data"]. *Mir transporta*. 15. 6(73): 20-30. [in Russian]

Oznamets, 2023 – *Oznamets. V.V.* (2023). The Evolution of Space Geodesy. *Russian Journal of Astrophysical Research. Series A*. 9(1): 14-19.

Oznamets, Tsvetkov, 2019 – Oznamets, V.V., Tsvetkov, V.Ya. (2019). Space Geodesy of Small Celestial Bodies. *Russian Journal of Astrophysical Research. Series A*. 5(1): 30-40.

Savinych, 2022 – *Savinych, V.P.* (2022). Study of the "earth-moon" system. *Russian Journal of Astrophysical Research. Series A*. 8(1): 32-39.

Tsvetkov, 2012 – *Tsvetkov, V.Ya*. (2012). Framework of Correlative Analysis. *European researcher*. 6-1(23): 839-844.

Tsvetkov, 2014 – *Tsvetkov, V. Ya*. (2014) Opposition information analysis. European Journal of Technology and Design. – 2014. № 4(6). P.189-196 DOI: 10.13187/ejtd.2014.6.18

Tsvetkov, 2023 – *Tsvetkov, V.Ya*. (2023). Satellite Monitoring. *Russian Journal of Astrophysical Research. Series A*. 9(1): 24-27.

Wu et al., 2019 – *Wu, S.W., Wang, G., Wang, Q., Jia, Y.D., Yi, J., Zhai, Q.J., ... , Zhang, T.Y.* (2019). Enhancement of strength-ductility trade-off in a high-entropy alloy through a heterogeneous structure. *Acta Materialia*. 165: 444-458.

Published in the USA
Russian Journal of Astrophysical Research. Series A
Issued since 2013.
E-ISSN: 2413-7499
2024. 10(1): 18-21

DOI: 10.13187/rjar.2024.1.18
https://rjar.cherkasgu.press

Space Transport Cyber Space

Vladimir V. Litvinov [a], [*]

[a] Russian Technological University (RTU MIREA), Moscow, Russian Federation

Abstract

The article explores space transport cyberspace as a tool for controlling ground transport and spacecraft. Space transport cyberspace has two areas of application: space and ground. Space direction is associated with the control of spacecraft, ground control is associated with the management of ground transport. The role of monitoring in the use of space transport cyberspace is shown. The components of space transport cyberspace are described. The contents of the components of space transport cyberspace are disclosed. Support systems for space transport cyberspace are described. Coordinate systems are an essential component of space transport cyberspace. One of the main types of methodological support for space transport cyberspace is geoinformatics methods. The difference between information space and cyberspace is shown. The connection between cyberspace and the information field is shown. Cyber space is considered as a synthesis of space, network organization, information field and information space. An analysis of the concept of the term "space" and its relationship to the term cyberspace has been carried out. The article introduces the term "Space transport cyber space". A control mechanism using cyber space is described. Comic transport cyber space includes space transport and ground transport. Similar concepts are explored: network space, virtual space and cyber space of digital twins. For complex integrated management of a system of transport facilities, cyberspace is necessary.

Keywords: management, space transport cyberspace, ground transport, space transport, satellite technologies, information space.

1. Introduction

Space transport cyberspace has two areas of application: space and ground. The space direction is associated with the control of spacecraft and space carriers. Ground control is related to ground transportation management (Rosenberg et al., 2010). This direction is associated with the use of GPS and GLONASS systems. Information space is used to manage land transport (Oznamets, 2020). A type of information space is the information transport space (ITS). This space is used for different purposes: management, monitoring (Tsvetkov, 2005), development of transport infrastructure, to support intelligent transport systems (Tsvetkov, Rosenberg, 2012), to support intelligent logistics systems (Kovalský, Mič ieta, 2017), transport cyber physical systems (Liu et al., 2017; Levin, Tsvetkov, 2018). ITS is used in the control of high-speed traffic.

The development of management is accompanied by the development of theory and technology. Currently, models of information space, models of the information field (Raev, 2021) and models of cyberspace are used in transport management. The term cyberspace has appeared in industry and network technologies. This concept is applicable in space research and transport

[*] Corresponding author
E-mail addresses: litvinov@mireru (V.V. Litvinov)

management. By analogy with ITS, the term "Space Transport Cyberspace" (STCS) can be introduced) Space transport cyberspace has two subspaces: terrestrial and space. Ground-based space transport cyberspace is designed to control air, rail, sea and road transport. The space segment of space transport cyberspace is designed to control space transport.

Space transport cyberspace is a synthesis of the information space of the Internet, the Internet of Things and cognitive space. The most striking application of cyberspace in manufacturing is digital twin technology (Tao at al., 2022). Digital twin technology uses the cyberspace of dynamic information models and network models. Cyberspace is used in solving scientific and applied problems.

In a broad sense, the field of transport includes space transport: artificial Earth satellites, orbital stations and re-entry spacecraft. Space transport cyberspace has two main functions. The first function is related to transport cybersecurity. The second function is to support transport management. Unlike the passive information transport space, STCS is active.

2. Results and discussion

With STCS support

STCS requires comprehensive support. There are different types of support: coordinate, technological, methodological, model, controlling. Coordinate support is required for STCS (Rosenberg, Tsvetkov, 2009). The basis of support is coordinate systems. They are a mandatory component of osmic transport cyberspace. One of the main types of technological support STCS are currently satellite technologies (Vylegzhanin, Satdinov, 2020). One of the main types of methodological support for STCS is geoinformatics methods.

One of the main types of STC control support is various types of monitoring: geoinformation monitoring, satellite monitoring (Tsvetkov, 2023), geomonitoring (Hohensinn et al., 2021).

Basic Principles of Cyberspace

The development of cyber-physical systems technologies combined with cloud computing (Buravtsev, Tsvetkov, 2019) and fog computing has led to the emergence of cyberspace. Cyberspace (Mueller, 2020) is intelligent and more "soft" compared to the information space. Cyberspace uses not only the power of cloud computing, but also the ideas of virtual and mixed reality

In cyberspace, there is a two-way "mirroring". It consists in the fact that information from outer space is transferred to STCS, where it is analyzed before decisions are made. The decision-making model is played in the virtual space and only after that it is implemented. STCS interprets managerial, informational and representational aspects. In the managerial sense, the concept of STC is interpreted as a set of principles of cybernetics that simulate the actions of a real system. The main components of STCS are Orderliness, Integrity, Symmetry, Completeness, Universality.

The integrity of the system guarantees the reliability of the data. Validity in the logical sense means that either all the data (D) contained in the IEM container is valid, or it is unreliable (D¬) all together. Intermediate states are excluded. This principle is formalized in expression (1).

$$D \vee \neg D = 1 \quad (1)$$

Completeness means the closeness and security of the repository of cyberspace.

All information about the object or objects is placed in a closed container, inside which the virtual and real system of objects functions. If we denote these systems of objects as D, and external influences as E, then the principle of closure can be written in the form of expression (2).

$$D \cap E = (\varnothing 2)$$

Orderliness entails the systematization and standardization of all business processes entered into the system circuit (Fig. 1). Simultaneous ordering of all business processes is the transfer of the enterprise from a state of uncertainty to formalized controllability. It is possible to use a special information management language *Lc,* which includes a standard set of information units of operations and units for the formation of operations. Multiple chains of operations (MChO) belongs to that language. This is reflected in expression (3)

$$MChO \subseteq Lc \quad (3)$$

Symmetry means a dynamic symmetric model of a real and virtual system of objects. The system implements a symmetrical digital model, a one-to-one cybernetic reflection of controlledtransport objects. A real object model (ROM) exists in reality. A virtual model is created by a VOM object in the virtual parameter space VP.A digital model of objects DOM is created in the space of digital parameters DP. Between them there is an information correspondence *I*, shown in expression (4).

I(ROM)=I(DAboutM) (4)

Expression (4) describes the information symmetry of the states of the original and the digital twin. The parameters of the virtual VOM model evolve synchronously with changes in the situation in real space. This dynamic process is illustrated in expression (5).

ΔS(ROM) $\rightarrow\Delta$RP (5)

Expression (5) means that a change in the state of the system of real transport objects ΔS(ROM) in real space entails a change in the parameters ΔRP of the real system of objects. This change ΔRP entails a change in the parameters of ΔDP in the virtual digital space. This causal process is reflected by expression (6).

ΔRP $\rightarrow\Delta$DP (6)

Changing the parameters ΔDP of the object system entails a change in the state of the virtual object system ΔS (ROM) in the virtual space. This management process is reflected in expression (7).

ΔDP $\rightarrow\Delta$S (DOM) (7).

Changing the state of the digital system of objects when using the control language or control rules produces control actions on the system of digital objects. The process is shown in expression (8).

ΔS (DOM) $\cap$Lc$\rightarrow$Cd (DOM) (8)

Control actions on the digital system of transport facilities are replicated into the real space of transport facilities. It creates a real control action (Cd) on real transport objects. The management process is described in expression (9).

Cd (DOM) $\rightarrow$Cd (ROM) (9)

Control actions on a real transport object or a system of objects transfer them to a new physical state S *. This management process is reflected in (10).

Cd (ROM)$\rightarrow$ S*(ROM) (10)

This is how real ground or space objects are controlled. In such a cyberspace, symmetry is used between transport objects and their digital or virtual twins. Formulas (4) – (10) describe the control chain of real transport objects using their virtual or digital images in cyberspace.

3. Conclusion

Cyberspace contains information space and information field. For the integrated management of a system of objects, cyberspace is necessary. For management, virtual or digital images of transport objects are used. These images can describe spacecraft or ground transport. The creation of virtual images is possible only in cyberspace. Therefore, only cyberspace provides the possibility of such control. The term space cyberspace is relatively new and is used in different contexts. This paper examines space transport cyberspace. The organization of space transport cyberspace is mandatory in the development of high-speed transport. The organization of space transport cyberspace is mandatory in the management of spacecraft. Satellite technology is the backbone of support for space transport cyberspace.

References

Buravtsev, Tsvetkov, 2019 – *Buravtsev, A.V., Tsvetkov, V.Ya.* (2019). Oblachnye vychisleniya dlya bol'shikh geoprostranstvennykh dannykh [Cloud computing for big geospatial data]. *Informatsiya i kosmos*. 3: 110-115. [in Russian]

Hohensinn et al., 2021 – *Hohensinn, R., Stauffer, R., Raphael, S., Pinzon, I.D.H., Spannagel, R., Wolf, A., Rossi, Y., Rothacher, M.* (2021). Low-cost vs. Geodetic-grade GNSS Instrumentation: Geomonitoring with High-rate and Real-time PPP. *Proceedings of the 34th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2021)*. Pp. 3990-4001.

Kovalský, Mičieta, 2017 – *Kovalský, M., Mičieta, B.* (2017). Support planning and optimization of intelligent logistics systems. *Procedia engineering*. 192: 451-456.

Levin, Tsvetkov, 2018 – *Levin, B.A., Tsvetkov, V.Ya*. (2018). Kiberfizicheskie sistemy v upravlenii transportom [Cyberphysical systems in transport management]. *Mir transporta*. 16. 2(75): 138-145. [in Russian]

Liu et al., 2017 – *Liu, Y. et al.* (2017). Review on cyber-physical systems. IEEE/CAA Journal of Automatica Sinica. 4(1): 27-40.

Mueller, 2020 – *Mueller, M.L.* (2020). Against sovereignty in cyberspace. *International studies review*. 22(4): 779-801.

Oznamets, 2020 – *Oznamets, V.V.* (2020). Informatsionnoe upravlyayushchee transportnoe prostranstvo [Information control transport space]. *Nauka i tekhnologii zheleznykh dorog*. 4. 4(16): 43-50. [in Russian]

Raev, 2021 – *Raev, V.K.* (2021). Informatsionnoe prostranstvo i informatsionnoe pole [Information space and information field]. *Slavyanskii forum*. 4(34): 87-96. [in Russian]

Rozenberg i dr., 2010 – *Rozenberg, I.N., Toni, O.V., Tsvetkov, V.Ya*. (2010). Integrirovannaya sistema upravleniya zheleznoi dorogoi s primeneniem sputnikovykh tekhnologii [Integrated railway control system using satellite technologies]. *Transport Rossiiskoi Federatsii*. 6: 54-57. [in Russian]

Rozenberg, Tsvetkov, 2009 – *Rozenberg, I.N., Tsvetkov, V.Ya*. (2009). Koordinatnye sistemy v geoinformatike [Coordinate systems in geoinformatics]. MGUPS, 67 p. [in Russian]

Tao at al., 2022 - *Tao, F., Xiao, B., Qi, Q., Cheng, J., Ji, P*. (2022). Digital twin modeling. *Journal of Manufacturing Systems*. 64: 372-389.

Tsvetkov, 2005 – *Tsvetkov, V.Ya*. (2005). Geoinformatsionnyi monitoring [Geoinformation monitoring]. *Izvestiya vysshikh uchebnykh zavedenii*. Geodeziya i aerofotos"emka. 5: 151-155. [in Russian]

Tsvetkov, 2023 – *Tsvetkov, V.Ya*. (2023). Satellite Monitoring. *Russian Journal of Astrophysical Research. Series A*. 9(1): 24-27.

Tsvetkov, Rozenberg, 2012 – *Tsvetkov, V.Ya., Rozenberg, I.N.* (2012). Intellektual'nye transportnye sistemy [Intelligent transport systems]. Saarbrücken, 297 p. [in Russian]

Vylegzhanin, Satdinov, 2020 – *Vylegzhanin, A.N., Satdinov, A.I.* (2020). Primenenie sputnikovykh tekhnologii v interesakh funktsionirovaniya zheleznykh dorog [Application of satellite technologies in the interests of the functioning of railways]. *Innovatsionnaya zheleznaya doroga. Noveishie i perspektivnye sistemy obespecheniya dvizheniya poezdov*. Pp. 85-92. [in Russian]

Published in the USA
Russian Journal of Astrophysical Research. Series A
Issued since 2013.
E-ISSN: 2413-7499
2024. 10(1): 22-27

DOI: 10.13187/rjar.2024.1.22
https://rjar.cherkasgu.press

Space Astronomy as a New Scientific Direction

Vladimir V. Oznamets [a, *]

[a] Moscow State University of Geodesy and Cartography (MIIGAiK), Moscow, Russian Federation

Abstract

The article explores space astronomy as a new scientific direction. Cosmic astronomy complements classical astronomy and is its development. Space astronomy can be considered as astronomy whose observation points are transferred from the earth's surface and near-Earth space into space onto space media. Space astronomy differs from classical astronomy not only in the transfer of observation points into outer space, but also in its methodological and organizational basis. Space astronomy, in addition to the basics of astronomy, uses new sciences as components: space geodesy, space geoinformatics, geodetic astronomy, spatial analysis, spatial logic, system analysis, computer science. The application of spatial logic is one of the features of space astronomy. The main means of observation in space astronomy is space monitoring, which uses the ideas of geoinformation monitoring. Space astronomy is a “situational” science. She not only observes, but also measures and forms management decisions. For example, the problem of selecting sites for landing spacecraft belongs to the field of space astronomy. The application of the information field model is an important difference in space astronomy. The information field is an integral model that unites different fields and allows for complex analysis and complex problem solving.

Keywords: space research, astronomy, space astronomy, space geoinformatics, space geodesy, information field.

1. Introduction

Space astronomy originated about 30 years after the launch of the first andsophisticated Earth satellites (AES). Since the launch of AES, Earth Remote Sensing (ERS) has been intensively developing. remote sensing of the Earth has a technological direction of research from space to Earth. Space astronomy (Zombeck, 2006) is directed from artificial earth satellites and spacecraft into space, that is, in the direction opposite to the Earth. Classical stronomy is conditioned by the needs of human practice in terrestrial and stellar coordination, in terrestrial navigation, in determining synchronous time, and studying the chronology of development. Classical astronomy studies the patterns of stellar and planetary arrangements. Astronomy studies the motion of celestial bodies, the structure of planetary systems, and the development of celestial systems and individual stars. Many definitions of astronomy do not refer to the direction of astronomy research. Astronomical research has long been carried out from the surface of the Earth into space. The creation of AES, orbital stations and spacecraft made it possible to transfer observations from the earth's surface to outer space. This created two directions of such observations. The first direction of observations is carried out from space to Earth. It is called remote sensing of the Earth (ERS)). For a long time, the second direction of observations from

* Corresponding author
E-mail addresses: voznam@bk.ru (V.V. Oznamets)

space to space was not called in any way. And recently, the name "space astronomy" has appeared for it. Space astronomy differs from classical astronomy not only in the transfer of observation points from the earth's surface to outer space, but also in its methodological and organizational basis. In some cases, space astronomy is implemented as a technological science. Its methods are aimed at solving applied problems. Space astronomy can be compared with geoinformatics, which at the beginning of development was created as a technological direction. The organizational components of space astronomy are: classical astronomy, geodetic astronomy (Gospodinov, 2018; Gospodinov, 2022), space geoinformatics (Bondur, Tsvetkov, 2015), space photogrammetry, dynamic photogrammetry, spatial logic, system analysis, computer science (Gospodinov, 2023; Polyakov, Tsvetkov , 2002) and space geodesy (Oznamets, 2023). Classical astronomy developed independently of geoinformatics. The main means of collecting information in space astronomy is space monitoring, which is carried out in different spectral ranges. Another difference between classical astronomy and space astronomy is the types of objects of observation. Classical stronomy is an "object" and "systemic" science. It examines objects and their systems. Space astronomy is an "object", "systemic" and "situational" science. It explores the spatial information situations in which objects are located, as well as systems of objects and systems of situations. Space astronomy considers the world as a system of systems (Monakhov i dr., 2004). Cosmic astronomy considers space as a system of nested spaces (Tsvetkov, 2015). In the modern world, information serves as the basis for development. Therefore, space astronomy uses the methods of computer science, which did not exist in the period of the emergence and application of conventional astronomy.

Modern informatics uses the concept and model of the information field (Raev, 2021) for integrated processing of observations. The concept of the information field of information is used in space research (Bondur, 2015). It is logical to apply this concept in space astronomy. Thus, space astronomy is a complex of sciences and its study is relevant.

2. Results and discussion

Cosmic spatial logic

Logic is interpreted as the science of reasoning. Recently, logic has been interpreted as the science of finding and describing the laws of the surrounding world. For space astronomy, spatial logic is important. Spatial logic (Kudzh, Tsvetkov, 2020; Tsvetkov, 2020) describes the patterns of spatial systems and structures. Spatial logic in space astronomy includes geometric logic, figurative logic, and visibility logic. The logic of visibility is due to the peculiarity of space observations. Objects, such as planets, are large in size compared to terrestrial objects. Space objects move with huge Speeds. Spatial logic is used in trajectory calculations and analysis. Observation distances in space are orders of magnitude greater than those in terrestrial conditions. Spatial logic is used in the construction of virtual models of outer space. Logic is necessary in the study of near-Earth space and the study of the surface of planets.

The peculiarity of space astronomy and space geoinformatics is the widespread use of angular measurements (Savinykh, 2021). Many studies of planets do not have the possibility of linear contact direct measurements. Most measurements in astronomy and space astronomy are angular. Cosmic spatial logic allows for spatial and geometric constructions. It connects real angular measurements with the linear dimensions of celestial bodies.

Coordinate systems in space astronomy.

Coordinate systems in space astronomy are used and developed on the basis of astronomical coordinate systems and terrestrial coordinate systems. Many of the tasks of space astronomy are related to measurements on the surface of planets. Different coordinate systems are used on the surfaces of the planets. The principle of system selection is similar to terrestrial coordinate systems (Rosenberg, Tsvetkov, 2009) Planetocentric, external, reference (model), surface (topocentric) coordinate systems and fragmentary (local) systems are used to model the surface of planets. On planets, as a rule, (with the exception of the Earth) it is difficult to create geodetic networks. Planetocentric coordinate systems are associated with the center of mass of the planet and are most often spherical. External coordinate systems have a conditional center. They are connected to the outer point of space and are not connected to the planet. They are usually also spherical or elliptical. Such a system is created in a conditional space relative to the planet and for its binding to the surface, points with known coordinates on the surface of the planet are required. An example of such systems are GPS, GLONASS systems. A planet is nested in this coordinate space and there is a need to bind this space to the surface or center of mass of the planet.

Surface (topocentric in relation to the earth's surface) coordinate systems are created relative to the points of the surface. They are tied to surface points. They are usually Cartesian coordinate systems. These systems are tied to a planet-centric system. Local coordinate systems are created in small areas to solve engineering problems. They are floating and are not tied to a planet-centric coordinate system. They are analogues of surface coordinate systems. They are created for the duration of engineering or construction work.

Planet-centric coordinate systems are associated with the center of mass of the planet. These coordinate systems are based on a model of the planet: either a spheroid or an ellipsoid. For an ellipsoid model, you need to specify the parameters of the ellipsoid, the plane of the equator, the poles, and the center. A planetary ellipsoid is used to simulate the shape of a planet if it looks like an ellipsoid. Therefore, the main task of such a model is to model the shape.

Reference coordinate systems are associated with the reference ellipsoid model. These systems are used for the studied areas. An additional procedure is the orientation of the reference ellipsoid in the body of the planet.Reference ellipsoids define a system of heights. Therefore, in contrast to the planetary ellipsoid, it is necessary to set the initial geodetic dates (*datum*) to orient and fix the reference ellipsoid in the body of the planet. The main task of such a model is to simulate heights on the surface of the planet.

The topocentric coordinate system is rectangular. Its origin is on the surface of the planet, near the surface or below the surface. The direction of the Z-axis is chosen along the normal to the surface of the planet model (spheroid or ellipsoid). The *x-axis* lies in the plane of the meridian, which passes through the reference point. It is directed to the North Pole. Y-axis complements the educated system to the left. The system participates in the daily rotation of the planet, remaining stationary relative to the points of the surface. Such conditions for specifying planetocentric and topocentric systems ensure the comparability of measurements on different planets.

The Z-axis of the topocentric system sets the conditional vertical and serves as the basis for measuring heights on the planet. However, there are many contradictions in the geodetic literature. "A vertical is a straight line in space, perpendicular to the horizontal plane." Horizontal planes do not exist in nature. The surface of any planet is not a horizontal, but a convex surface. Most large planets have a shape close to spherical. Therefore, other approaches must be used to determine heights.

Many planets have the geometric center of the planet's figure shifted relative to the planet's center of mass. Because of this, the direction of the plumb line does not correspond to the direction of the vertical for the ellipsoid references.

The relationship of space astronomy to computer science and geoinformatics.

Informatics (Gospodinov, 2023) and geoinformatics (Ivannikov et al., 2005) have had a great influence on the development of science and technology. This is mainly due to the use of various models that generalize the properties of real-world objects. In addition, computer science and geoinformatics allow you to transfer processing and analysis methods from one field to another. Space astronomy is closer to applied computer science than to computer science. Space astronomy closer to applied computer science than to computer science. Space astronomy is closer to applied geoinformatics (Ivannikov et al., 2005) than to general geoinformatics. The application of geoinformatics methods is due to the property of its integration (Maksudova et al., 2000). It is advisable to use this property in space astronomy.

Geoinformatics uses artificial intelligence methods (Savinykh, Tsvetkov, 2010). Space astronomy also requires the use of artificial intelligence, especially due to the fact that there is a problem of big data in it

Information models are the basis of processing in computer science and geoinformatics (Tsvetkov, 2005a). This principle has been transferred to space astronomy

Space astronomy relies on qualitative and comparative analysis. In comparative analysis in space astronomy, oppositional analysis is used (Tsvetkov, 2008).

The basis of observation in space geoinformatics is geoinformation monitoring (Tsvetkov, 2005b) and space monitoring. In space astronomy, this is the main source of information.

In computer science and geoinformatics, digital models are widely used at the intermediate stage of processing. As a result of processing, digital maps are used (Tsvetkov, 2000). In space astronomy, maps are used less often and synthesized images and photo schemes are used more often.

Metamodeling is used to generalize experience in computer science and other sciences

(Tsvetkov at al., 2020). In space astronomy, metamodeling is also used to generalize experience and build hypotheses.

Field concept in space astronomy

A field concept in space astronomy is that modeling and analysis take into account the model of the information field (Bondur, 2015). Reality is considered by its reflection in the information field. The information field has three functions (Tsvetkov, 2014a): reflection, integration and representation. The mechanism of reflection is to reflect reality in the global information model of the information field. Function integration consists in the fact that the information field unites disparate and related objects, including their connections and relationships. The function of representation is that the information field represents objects and situations in visual form. It was noted above that space astronomy can be compared with a satellite image. The information field, as well as a photograph, reflects reality. Therefore, conceptually, the information field fits into the theory of space astronomy.

The information field includes not only specific objects, but also information uncertainty. Information uncertainty refers to information that can be explained logically and on the basis of known theories. On this basis, explanatory information and uncertainty are distinguished. There is a lot of redundant information in the information field. For example, a raster photograph contains as much information as a map of the area. But it has an information volume of 3-4 orders of magnitude larger than the information volume of the map.

The addition of the information field is the information space. An example of an information space in a spacecraft is coordinate space. The information space contains different information fields. The information field has a meaningful characteristic of the space field function, the field function shows the value of the characteristic of the field at a given point in space. For example, a satellite receiver shows three-dimensional coordinates at a point in space. The presence of a field function indicates the presence of a field, the absence of a field function indicates the absence of a field. The information space is polymorphic. For example, the coordinate of a point in space can be defined in a polar coordinate system, a Cartesian coordinate system, a spherical coordinate system, a cylindrical coordinate system.

3. Conclusion

Space astronomy arose as a development of astronomy to solve applied problems. Because of this, space geoinformatics is about space astronomy. Space geoinformatics developed on the basis of applied geoinformatics, which is focused on solving applied problems. Space astronomy based on the traditions of geoinformatics is developing through the integration of various scientific areas (Savinykh, 2015). As the first feature of the integration of space astronomy, it should be noted its integration with remote sensing technologies. As the second feature of the integration of space astronomy, it should be noted the transformation of Earth sciences into space disciplines: space geoinformatics, space geodesy (Jin et al., 2013), geodetic astronomy, and so on. As the third feature of space astronomy, it is necessary to note the problem of big data (Buravtsev, Tsvetkov, 2019), which is characteristic of space research. Space astronomy shapes spatial knowledge (Tsvetkov, 2016) and cosmic knowledge (Savinych, 2016). Space astronomy research methods are aimed at the study of celestial bodies. Space astronomy (Gospodinov, Tsvetkov, 2023) complements astronomy and space geoinformatics and contributes to the formation of a scientific picture of the world.

References

Bondur, 2015 – *Bondur, V.G.* (2015). Informatsionnye polya v kosmicheskikh issledovaniyakh [Information fields in space research]. *Obrazovatel'nye resursy i tekhnologii*. 2(10): 107-113. [in Russian]

Bondur, Tsvetkov, 2015 – *Bondur, V.G., Tsvetkov, V.Ya.* (2015). New Scientific Direction of Space Geoinformatics. *European Journal of Technology and Design*. 4(10): 118-126.

Buravtsev, Tsvetkov, 2019 – *Buravtsev, A.V., Tsvetkov, V.Ya.* (2019). Oblachnye vychisleniya dlya bol'shikh geoprostranstvennykh dannykh [Cloud computing for big geospatial data]. *Informatsiya i kosmos*. (3): 110-115. [in Russian]

Gospodinov, 2018 – *Gospodinov, S.G.* (2018). The Development of Geodesic Astronomy. *Russian Journal of Astrophysical Research. Series A*. 4(1): 9-33.

Gospodinov, 2022 – *Gospodinov, S.G.* (2022). Evolution of geodetic astronomy. *Russian Journal of Astrophysical Research. Series A*. 8(1): 3-11.

Gospodinov, 2023 – *Gospodinov, S.G.* (2023). Sovremennaya informatika [Modern computer science]. Saarbruken, 157 p. [in Russian]

Gospodinov, Tsvetkov, 2023 – *Gospodinov, S.G, Tsvetkov, V.Ya.* (2023). Nekotorye teoreticheskie aspekty instrumental'nykh metodov kosmicheskoi astronomii [Some theoretical aspects of instrumental methods of space astronomy]. Sofiya. Art Eternal Cinema. 92 p. [in Russian]

Ivannikov i dr., 2005 – *Ivannikov, A.D., Kulagin, V.P., Tikhonov, A.N., Tsvetkov, V.Ya.* (2005). Prikladnaya geoinformatika [Applied geoinformatics.]. M.: MAKS Press, 360 p. [in Russian]

Jin et al., 2013 – *Jin, S., van Dam, T., Wdowinski, S.* (2013). Observing and understanding the Earth system variations from space geodesy. *Journal of Geodynamics*. 72: 1-10.

Kudzh, Tsvetkov, 2020 – *Kudzh, S.F., Tsvetkov, V.Ya.* (2020). Spatial logic concepts. *Revista inclusions*. 7. Número Especial / Julio – Septiembre. Pp. 837-849.

Maksudova i dr., 2000 – *Maksudova, L.G., Savinykh, V.P., Tsvetkov, V.Ya.* (2000). Integratsiya nauk ob okruzhayushchem mire v geoinformatike [Integration of sciences about the surrounding world in geoinformatics]. *Issledovanie Zemli iz kosmosa*. 1: 46-50. [in Russian]

Monakhov i dr., 2004 – *Monakhov, S.V., Savinykh, V.P., Tsvetkov, V.Ya.* (2004). Metodologiya analiza i proektirovaniya slozhnykh informatsionnykh system [Methodology for analysis and design of complex information systems]. M.: Prosveshchenie, 264 p. [in Russian]

Oznamets, 2023 – *Oznamets, V.V.* (2023). The Evolution of Space Geodesy. *Russian Journal of Astrophysical Research. Series A*. 9(1): 14-19.

Polyakov, Tsvetkov, 2002 – *Polyakov, A.A., Tsvetkov, V.Ya.* (2002). Prikladnaya informatika [Applied Informatics]. M.: Yanus-K, 392 p. [in Russian]

Raev, 2021 – *Raev, V.K.* (2021). Informatsionnoe prostranstvo i informatsionnoe pole [Information space and information field]. *Slavyanskii forum*. 4(34): 87-96. [in Russian]

Rozenberg, Tsvetkov. 2009 – *Rozenberg, I.N., Tsvetkov, V.Ya.* (2009). Koordinatnye sistemy v geoinformatike [Coordinate systems in geoinformatics]. MGUPS, 67 p. [in Russian]

Savinych, 2016 – *Savinych, V.P.* (2016). On the Relation of the Concepts of Space Knowledge, Knowledge, Knowledge of the Spatial. *Russian Journal of Astrophysical Research. Series A*. 1(2): 23-32.

Savinykh, 2015 – *Savinykh, V.P.* (2015). O kosmicheskoi i zemnoi geoinformatike [About space and terrestrial geoinformatics]. *Perspektivy nauki i obrazovaniya*. 5: 21-26. [in Russian]

Savinykh, 2021 – *Savinykh, V.P.* (2021). Determination of the Linear Parameters of the Planet by Measuring the Angular Diameter. *Russian Journal of Astrophysical Research. Series A*. 7(1): 28-34.

Savinykh, Tsvetkov, 2010 – *Savinykh, V.P., Tsvetkov, V.Ya.* (2010). Razvitie metodov iskusstvennogo intellekta v geoinformatike [Development of artificial intelligence methods in geoinformatics]. *Transport Rossiiskoi Federatsii*. 5: 41-43. [in Russian]

Tsvetkov et al., 2020 – *Tsvetkov, V.Ya., Shaitura, S.V., Minitaeva, A.M., Feoktistova, V.M., Kozhaev, Yu.P., Belyu, L.P.* (2020). Metamodelling in the information field. *Amazonia Investiga*. 9(25): 395-402.

Tsvetkov, 2000 – *Tsvetkov, V.Ya.* (2000). Tsifrovye karty i tsifrovye modeli [Digital maps and digital models]. *Izvestiya vysshikh uchebnykh zavedenii*. Geodeziya i aerofotos"emka. 2: 147-155. [in Russian]

Tsvetkov, 2005a – *Tsvetkov, V.Ya.* (2005). Informatsionnaya model' kak osnova obrabotki informatsii v GIS [Information model as the basis for information processing in GIS]. *Izvestiya vysshikh uchebnykh zavedenii*. Geodeziya i aerofotos"emka. 2: 118-122. [in Russian]

Tsvetkov, 2005b – *Tsvetkov, V.Ya.* (2005). Geoinformatsionnyi monitoring [Geoinformation monitoring]. *Izvestiya vysshikh uchebnykh zavedenii*. Geodeziya i aerofotos"emka. 5: 151-155. [in Russian]

Tsvetkov, 2008 – *Tsvetkov, V.Ya.* (2008). Ispol'zovanie oppozitsionnykh peremennykh dlya analiza kachestva obrazovatel'nykh uslug [Using oppositional variables to analyze the quality of educational services]. *Sovremennye naukoemkie tekhnologii*. 1: 62-64. [in Russian]

Tsvetkov, 2014a – *Tsvetkov, V.Ya.* (2014). Information Space, Information Field, Information Environment. *European researcher*. 8-1(80): 1416-1422.

Tsvetkov, 2015 – *Tsvetkov, V.Ya.* (2015). Kosmicheskii monitoring: Monografiya [Space monitoring: Monograph]. M.: MAKS Press, 68 p. [in Russian]

Tsvetkov, 2016 – *Tsvetkov, V.Ya.* (2016). Formirovanie prostranstvennykh znanii: Monografiya [Formation of spatial knowledge: Monograph]. M.: MAKS Press, 68 p. [in Russian]

Tsvetkov, 2020 – *Tsvetkov, V.Ya.* (2020). Prostranstvennaya logika v geoinformatike [Spatial logic in geoinformatics]. *Vektor GeoNauk*. 3(2): 91-100. [in Russian]

Zombeck, 2006 – *Zombeck, M.V.* (2006). Handbook of space astronomy and astrophysics. Cambridge University Press.

Published in the USA
Russian Journal of Astrophysical Research. Series A
Issued since 2013.
E-ISSN: 2413-7499
2024. 10(1): 28-33

DOI: 10.13187/rjar.2024.1.28
https://rjar.cherkasgu.press

Information Approach in Space Research

Viktor P. Savinych [a], [*]

[a] Moscow State University of Geodesy and Cartography, Moscow, Russian Federation

Abstract

The article explores the information approach as one of the methods for obtaining knowledge in space research. The advantage of the information approach is that it systematizes research and systematizes the use of models in solving typical problems. The universality of models in the information approach allows the transfer of knowledge from one area of research to another area of research. The versatility of the models allows you to gain experience. The article describes the current state of the information approach. The main stages of the information approach are described. The main aspects of using the information approach are described. The information approach includes a set of principles and methods. Important components of the information approach include: information space, information field, information technology, information systems, onomasiological modeling, information models, information units, information situations, semasiological modeling, solving applied problems. The basic concept of the information approach uses the concept of an "information field" model. The information approach arose within the framework of earth sciences, but is fully applicable in space research. Space research uses information models and simulations. Space research uses the ideas of geoinformatics and geoinformation models. Models of spatial relationships and georeferences are important in the information approach for space research. The main objective of the information approach in space research is to obtain new knowledge and spatial knowledge. An additional task of the information approach in space research is to obtain information resources and accumulate experience in space research.

Keywords: information, information approach, space research, information field, information modeling.

1. Introduction

Modern space research has a number of features. One of the features of modern space research is the application of the information approach (IA), transformed taking into account space information. The ideas of the information approach are embedded in applied informatics (Polyakov, Tsvetkov, 2002). A variety of models are a tool for cognition in space information research (Raev, 2020). The application of the information approach in space research is based on the widespread use of computer science methods. The information approach systematizes research, as well as systematizes the construction and application of models in solving typical problems. The main information models in space research are spatial models. They are analogues of geoinformation models and are divided into topological, mathematical and informational. Spatial information models, within the framework of the information approach, have the property of universality. The versatility of the models allows you to transfer

[*] Corresponding author
E-mail addresses: president@miigaik.ru (V.P. Savinych)

knowledge from one field of study to another area of research. The versatility of the models allows you to accumulate experience. The versatility of the models allows you to build theoretical constructions and find patterns. Topological models usually describe the structure. Mathematical models define functional analytics. Information models define the description and presentation. The universality of mathematical models consists in the use of the same formulas to describe different processes or objects. The universality of topological models consists in a generalized description of structures and, on this basis, the transfer of the study of the structures of different objects. The universality of information models consists in the use of a common space of parameters and a common information field to describe and compare different objects and phenomena. Thus, the information approach uses different types of models. The information approach uses methods of qualitative and quantitative analysis. An addition to the information approach in space research is logical design, which serves as a means of verifying and improving the reliability of research. Information models in space research are mostly descriptive.

2. Results and discussion

The current state of the information approach.

The information approach as a method of scientific research and knowledge of the world around us has more than half a century of history (Neimark, Strongin, 1966; Theil, 1965). Currently, the information approach is widely used in modeling, in education, in psychology, in management, in philosophy, in system analysis, in solving complex problems, in spatial analysis, etc. The information approach is considered as a tool for understanding the world around us (Tsvetkov, 2014; Kovalenko, 2015) and is closely related to the system approach (Bondur, Tsvetkov, 2015) in space research. In practice, a person uses meaningful information or knowledge. The first step of the information approach is to collect information and extract meaningful information from it. In the aspect of research, the information approach is closely related to information technology. In the aspect of describing the surrounding world, the information approach is associated with descriptive models and various theories such as topology, geometry, and artificial intelligence. The information approach is implemented in three aspects: systemic, conceptual and technological.

In the system sense, the information approach is a technological system. It is a coherent set of methods and technologies that form an integral system. In the system aspect, the information approach includes system components that form a technological system. These system components are as follows: reflection of the properties of the real world with the help of tools; formation of information about the world on the basis of reflection; analysis of this information; building information relationships and connections; construction of information models; Modelling and metamodelling

Conceptually, the information approach is a set of principles and methods. The conceptual components of the information approach include: information space, information field, information technology. information systems, onomasiological modeling, information models, information units, information situations. semasiological modeling, solution of applied problems. As the main concept, the information approach uses the concepts of "information field" (*Kudzh*, 2017), "information model", "information relations", "information interactions".

Technologically, the information approach is a system of methods and technologies for solving practical problems of cognition and design of projects. Technologically, the information approach includes the following components:

- information description of the surrounding world based on a connected system: information units (Ozhereleva, 2014), information models and information structures;
- system analysis of the results of the study, including the use of information relations;
- modeling of information relations (Chekharin, 2016);
- modeling of information interactions;
- information and cognitive modeling (Tsvetkov, 2013);
- application of information models for solving practical problems.
- extraction of knowledge from the information field;
- the transformation of tacit knowledge into explicit knowledge (Kuj, 2018).

The description of the surrounding world in accordance with the information approach reflects the hierarchy of the world. At the lower level, information units as the basis of the description. At the next level, information models and the third level of description make up information constructs. The main structural elements of the information approach.

The description of the surrounding world in accordance with the information approach requires the use of a set of qualitatively different models. When collecting information, it is necessary to distinguish and apply fact-fixing and interpretive models. When describing objects and phenomena, it is necessary to distinguish between models for describing processes and models for describing static objects. According to this criterion, descriptive (Ozherelyeva, 2016) and prescriptive models are divided.

The information approach ensures continuity between manual, automated and intelligent research methods. It creates opportunities for improving research methods and accumulating information research experience recorded in objective, independent models and descriptions. The main advantage of the information approach is that it creates opportunities for interdisciplinary transfer of research experience and logical-mathematical methods.

Specificity of the information approach.

The Information Approach in Space Research (IASR) uses osmicgeodesy (Bertiger et al., 2020; Oznamets, 2023) and space geoinformatics (Bondur, Tsvetkov, 2015). IASR uses remote non-contact methods and predominantly angular measurements. The information approach in space research uses spatial logic (Tyagunov, Tsvetkov, 2021) to a greater extent than ground-based methods.

The information approach in space research can be compared with obtaining a satellite image. It includes remote information collection (image acquisition), analysis of primary information (qualitative analysis of the image), structural analysis of information (interpretation of the image), model building, visualization of models, qualitative, quantitative and comparative analysis. Is the information content of satellite imagery higher? Than ground or aerial photography. This makes it difficult to process.

IASR includes the following stages: problem setting; building information models, observation and analysis; obtaining new knowledge.

The stage of setting the problem. This phase includes the following processes:

The conditions of the study or the conditions for solving a scientific problem are formulated.

The general goal and particular goals of the study are formulated

An information object is defined as a model of a real object of research.

The information need of the study is determined – this is the need that arises in the process of scientific research, when the purpose of the study or the solution of a scientific problem cannot be achieved without the involvement of additional information in the form of data, information products or measurements. The information need is formed on the basis of understanding and comprehension of the situation in which the object of study is located. Satisfying the information needs of the study is preceded by solving a scientific problem

Define the information resources of research as a set of technical and methodological tools, information systems, processing methods, theoretical hypotheses available to the researcher.

Stage of building information models

In information technologies and systems, only information models are used for processing. Information models are divided into two classes: description models (semantic models) and processing models (procedural models).

Semantic models are an association of semantic units that reflect the properties of the object of study. They are related to the theory and our knowledge of the object of study. As a result of the study, these models are expanded, refined and new models appear.

Procedural models are a combination of logical information units. They are associated with the logic of information processing, with the computer representation of information. At the stage of building information models, an information search is carried out for models that can be used to process and analyze space research data.

The basic semantic models are: models of information space, models of information situations and models of information positions. At this stage, the following processes are carried out.

An information model of the object of observation – an information object – is formulated.

A model of the information situation in which the object of observation is located is formulated.

A model of spatial relations in which the object of observation is located is formulated.

A model of the information position in which the object of observation is located is formulated.

A model of the information state in which the object of observation is located is formulated.

Models of nested information spaces are formulated:

- the space of the environment in which the object of observation and the observation system are located (long-range field of observation);
- the space of the environment of the object of observation (the average field of observation);

- the space of the object of observation (the near field of observation, including the information positions of the object of observation);
- the space of the environment of the observation system (the field of recording the results of observations, including the information positions of the observation system);
- the space of the observation system (including information resources, models and technologies – observation systems).

Observation and Analysis Phase: This level includes the following processes:

The conditions for the uniformity of measurements are formulated. The vector of the research goal is defined as an ordered list of particular research goals that describes the objective ideal (in the sense of setting a scientific problem) result of the study of the object of observation.

The information field of observations is evaluated as a complex of observed multi-level information spaces and objects, information processes, connections and relations, united by a common semantic meaning – a reflection of outer space. The main function of this field is descriptive

A multidimensional matrix of possible states of the object of observation is determined. The observation cycle is carried out as a repeated repetition of the observation stages until the goal of the study is achieved.

After receiving the data, facts and parameters, the analysis is carried out.

The information situation of the object of observation is determined on the basis of the current assessment of the state of the external environment. The information position of the object of observation is determined on the basis of the current assessment of the state of the object of observation in relation to the external environment in the information field. Modeling and prediction of the dynamics of the states of the object of observation and the environment is carried out.

Level of knowledge. This level includes the stages of constructing a terminological field, building a knowledge base, extracting knowledge of their observation facts and the results of processing spatial data.

One of the main tasks of space research is to obtain spatial knowledge (Tsvetkov, 2016). In scientific research, the concept of geoknowledge (Tsvetkov, 2016) is increasingly being used as knowledge related to spatial relationships. Geoknowledge in space research is considered as a form of knowledge associated primarily with spatial relations in the space of the surface.

Using interdisciplinary transfer, the concept of "spatial knowledge" or geo-knowledge can be used. Spatial knowledge is a form of knowledge related to spatial relations in outer space. Spatial knowledge in space research reflects knowledge about spatial space objects, and knowledge about spatial and non-spatial relationships. Hence the possibility of a broader description of such knowledge. Knowledge about objects in the theory of artificial intelligence, as a rule, uses descriptions based on the traditional linguistic or analytical form.

Spatial knowledge about space objects can be adequately conveyed not only in the traditional form, but also in additional descriptions (maps, digital models, images, pseudo-images, three-dimensional visualizations, spatial topological schemes).

An important ontological characteristic of spatial cosmic knowledge is reference. There is a concept of geo-reference (Hackeloeer et al., 2014) as a means of describing the acquisition of knowledge about terrestrial objects. Spatial relationships are the basis of georeference.

By analogy, you can introduce the concept of "spatial reference" Spatial reference is a means of describing, obtaining knowledge about objects in outer space. It is also based on the application of spatial relations, but in outer space.

A spatial reference, defined by a name that carries the characteristics of a relationship or a description of an object, is called an identifying reference. An identifying reference is associated with the identifier of a space research object and uses three types of relationships*: indication, naming, and designation*.

The choice of the relationship in the identification of the object of space research is determined by the following rules. The relation "designation" is used in a situation of an explicit description of the object of study. In mathematics, it corresponds to an explicit description of a function.

The relation "naming" is used in a situation of implicit description of the object of space research. In mathematics, it corresponds to an implicit description of a function. The relation "naming" is used in the absence of a description of the object, but the presence of other objects associated with the object of study. These objects are in a spatial relationship with the object of study. In mathematics, this relation corresponds to a set of constraints that define the scope of existence.

When introducing a new concept, it is advisable to give similarities and differences with similar concepts. Structurally, spatial knowledge differs from the knowledge used in management and the theory of artificial intelligence. This is due to the following main reasons:

Linguistic aspect. Binding to a specific subject area narrows the scope of the concept;

Integration aspect. The emergence of additional relationships and connections makes it possible to combine different types of information and knowledge and obtain new models and new knowledge on this basis.

Spatial knowledge as a subset is a union of declarative (D), procedural (P), and configurational C sets.

$$GK = D \cup P \cup C \quad (1)$$

The sets D and P have an empty intersection of D P = , $\cap$ so they are disjunctive. In the theory of artificial intelligence, such a description is the basis. In spatial knowledge, another component appears, called configurational. It is this component that distinguishes spatial knowledge from knowledge used in artificial intelligence.$\varnothing$

Another difference between spatial knowledge is the possibility of its visual *display* on maps, diagrams, photographic images and other types of images. When displaying, special transformations are used to represent spatial knowledge in a visual form convenient for analysis. To denote the mapping of the set φ *A* to the set *B*, the notation is used:

$$\varphi: A\ B \rightarrow (2)$$

If x *A*, $\in$ then the set of all elements from *B*, mapped to the element x, is φ denoted by *(*x*)*φ and is called the *image of the element x*. Due to the transformation (2) in spatial knowledge, topological models are widely used. The use of the information approach provides additional opportunities for representing, analyzing and solving problems in space research

3. Conclusion

The information approach in space research differs from the information approach in ground conditions. These differences are due to the methods of collecting information, processing methods, verification methods and the types of logics used. The information approach in terrestrial conditions is object-based, that is, it is aimed at studying individual objects. The term object includes the concept of process. The information approach in space research is situational. He explores situations first. The information approach in space research is dynamic. He explores moving objects. Therefore, it is necessary to use models of "spatial situations" in space research. The specifics of IASR include its distinctive characteristics and implementation features. IASR cannot be reduced only to instrumental and technological processes, as in computer science. The information approach in space research should be considered as an integrated approach that includes modeling and analysis.

References

Bertiger et al, 2020 – *Bertiger, W. et al.* (2020). GipsyX/RTGx, a new tool set for space geodetic operations and research. *Advances in space research*. 66(3): 469-489.

Bondur, Tsvetkov, 2015 – *Bondur, V.G., Tsvetkov, V.Ya.* (2015). System Analysis in Space Research. *Russian Journal of Astrophysical Research. Series A*. 1(1): 4-12.

Bondur, Tsvetkov, 2015b – *Bondur, V.G., Tsvetkov, V.Ya*. (2015). New Scientific Direction of Space Geoinformatics. *European Journal of Technology and Design*. 4(10): 118-126.

Chekharin, 2016 – *Chekharin, E.E.* (2016). Paradigmaticheskie i sintagmaticheskie otnosheniya v informatsionnom modelirovanii [Formation of spatial knowledge: Monograph]. *Perspektivy nauki i obrazovaniya*. 4: 13-17. [in Russian]

Hackeloeer et al., 2014 – *Hackeloeer, A., Klasing, K., Krisp, J. M., Meng, L.* (2014). Georeferencing: a review of methods and applications. *Annals of GIS*. 20(1): 61-69.

Kovalenko, 2015 – *Kovalenko, N.I.* (2015). Informatsionnyi podkhod pri postroenii kartiny mira [Information approach to constructing a picture of the world]. *Perspektivy nauki i obrazovaniya*. 6: 7-11. [in Russian]

Kudzh, 2017 – *Kudzh, S.A.* (2017). Informatsionnoe pole: Monografiya [Information field: Monograph]. M.: MAKS Press, 97 p. [in Russian]

Kudzh, 2018 – *Kudzh, S.A.* (2018). Neyavnye znaniya v informatsionnom pole [Tacit knowledge in the information field]. *Slavyanskii forum*. 3(21): 14-20. [in Russian]

Neimark, Strongin, 1966 – *Neimark, Yu.I., Strongin, R.G.* (1966). Informatsionnyi podkhod k zadache poiska ekstremuma funktsii [Information approach to the problem of searching for extremum of functions]. *Izvestiya Akademii nauk SSSR*. Tekhnicheskaya kibernetika. (1): 17-26. [in Russian]

Ozhereleva, 2014 – *Ozhereleva, T.A.* (2014). Systematics for information units. *European Researcher*. 11/1(86): 1894-1900.

Ozherel'eva, 2016 – *Ozherel'eva, T.A.* (2016). Deskriptivnye modeli [Descriptive models]. *Mezhdunarodnyi zhurnal prikladnykh i fundamental'nykh issledovanii*. 5-4: 675-675. [in Russian]

Polyakov, Tsvetkov, 2002 – *Polyakov, A.A., Tsvetkov, V.Ya.* (2002). Prikladnaya informatika [Applied Informatics]. M.: Yanus-K, 392 p. [in Russian]

Raev, 2020 – *Raev, V.K.* (2020). Informatsionnye modeli kak metod poznaniya [Information models as a method of cognition]. *Slavyanskii forum*. 2(28): 84-93. [in Russian]

Tsvetkov, 2013 – *Tsvetkov, V.Ya.* (2013). Kognitivnye aspekty postroeniya virtual'nykh obrazovatel'nykh modelei [Cognitive aspects of constructing virtual educational models]. *Perspektivy nauki i obrazovaniya*. 3: 38-46. [in Russian]

Tsvetkov, 2014 – *Tsvetkov, V.Ya.* (2014). Informatsionnoe opisanie kartiny mira [Information description of the picture of the world]. *Perspektivy nauki i obrazovaniya*. 5(11): 9-13. [in Russian]

Tsvetkov, 2016 – *Tsvetkov, V.Ya.* (2016). Formirovanie prostranstvennykh znanii: Monografiya [Formation of spatial knowledge: Monograph]. M.: MAKS Press, 68 p. [in Russian]

Tyagunov, Tsvetkov, 2021 – *Tyagunov, A.M., Tsvetkov, V.Ya.* (2021). Logic of Space Observations. *Russian Journal of Astrophysical Research. Series A*. 7(1): 43-48.

Oznamets, 2023 – *Oznamets, V.V.* (2023). The Evolution of Space Geodesy. *Russian Journal of Astrophysical Research. Series A*. 9(1): 14-19.

Theil, 1965 – *Theil, H.* (1965). The information approach to demand analysis. *Econometrica: Journal of the Econometric Society*. Pp. 67-87.

Tsvetkov, 2016 – *Tsvetkov, V.Ya.* (2016). Geoknowledge. *European Journal of Technology and Design*. 3(13): 122-132.

Published in the USA
Russian Journal of Astrophysical Research. Series A
Issued since 2013.
E-ISSN: 2413-7499
2024. 10(1): 34-37

DOI: 10.13187/rjar.2024.1.34
https://rjar.cherkasgu.press

Ergatic Systems in Space Research

Viktor Ya. Tsvetkov [a], *

[a] Department of Scientific Research, Analytics and Improvement of Scientific and Technical Activities, Research and Design Institute of design information, automation and communication on railway transport, Moscow, Russian Federation

Abstract

The article explores cosmic ergatic systems. The ergatic system is one of the types of complex systems that function with human participation. Not all such systems are ergatic. The system becomes ergatic with significant human involvement in its work. The article gives a definition of the ergatic system. The use of ergatic systems is a mandatory technology in space research. The article shows the difference between the human-machine system and the ergatic system in terms of parameters and areas of application. The term cosmic ergatic systems are introduced. Space ergatics systems are designed to control spacecraft and orbital stations. Space ergatic systems include control, navigation and prevention systems, in which humans play an important role. Three areas of application of space ergatic systems are shown. Structural diagrams of the human-machine system and the ergatic system are given. The features of ergatic space systems are described from the perspective of complex systems and from the perspective of system analysis. The article notes that many complex systems are not effective in complex situations. In these cases, it is necessary to use ergatic systems. The types and specialization of ergatic systems are shown. The ergatic cosmic system has the property of emergence. The emergence of such a system has different components: intellectual, cognitive, resource and others. This is the fundamental difference between cosmic ergatic systems and other complex systems. Comparing complex systems with ergatic or human-machine systems is possible only on the basis of the real situation and the tasks facing the system. The article shows that space ergatic systems can be considered as a type of heuristic and intelligent systems.

Keywords: complex systems, space research, space ergatic systems, cognitive interface, emergence.

1. Introduction

The development of space research is accompanied by the development of a number of related sciences: geodetic astronomy (Gospodinov, 2018; Gospodinov, 2022), space geodesy (Oznamets, 2023), space geoinformatics, space monitoring (Savinych, 2017; Kudzh, 2022). The development of space research has led to a new look at the concept of spatial knowledge and the emergence of the term cosmic knowledge (Savinych, 2016). The development of space research has led to the use of information field models in space research (Bondur, 2015). The development of space research has led to the emergence and development of space astronomy (Zombeck, 2006). The development of space research has led to the modernization of a number of existing systems.

* Corresponding author
E-mail addresses: cvj7@mail.ru (V.Ya. Tsvetkov)

One of these systems is the ergatic system.

Ergatic systems (ES) are systems in which a person is a block of the system and takes part in management or decision-making. For a long time, ergatic systems were identified with man-machine systems (MMS), but in recent decades there have been differences between them. Ergatic systems in space research have three areas of application: "cosmonaut-technology system", "cosmonaut-celestial body system", "mission control center operators - spacecraft".

Ergatic systems belong to the class of complex systems. Many complex systems function with human intervention, but not all systems are classified as ergatic. It all depends on the degree of human participation in the work of a complex system. There are a number of systems with human participation: human-machine, organizational, technological, automated, informational, cognitive, immersive intellectual, complex organizational and technical. Ergatic systems are used there, automated and even intelligent systems do not work. There are ergatic maritime transport systems (Nosov, 2020). They solve problems analysis of the situation by the navigator when passing in difficult places and port areas. In such problems, there is a need to apply spatial logic, which is realized only by humans. Ergatic systems are used in areas where operator involvement is an integral part of the effective functioning of complex or technical systems. In these areas, there is a need to quickly solve problems and emergency situations that arise in the process of work. Critical application systems are one of the varieties of ergatic systems. In air transport, ergatic systems arise in emergency situations when flying an aircraft (Pila, Kozuba, 2019) and in the work of dispatchers. Ergatic systems are used where there is information uncertainty and the so-called "non-factors" (Prokopenko et al., 2021), which include uncertainty, complexity, instability, ambiguity. Thus, the research and application of ergatic systems is a relevant modern direction.

Comparison of ergatic and human-machine systems.

The ergatic system is a new stage in the development of the human-machine system and is qualitatively different from it. Ergatic systems (ES) are more diverse than human-machine systems. To identify the differences between MMS and ES, consider the block diagrams of these systems. Figure 1 shows the block diagram of the MMS.

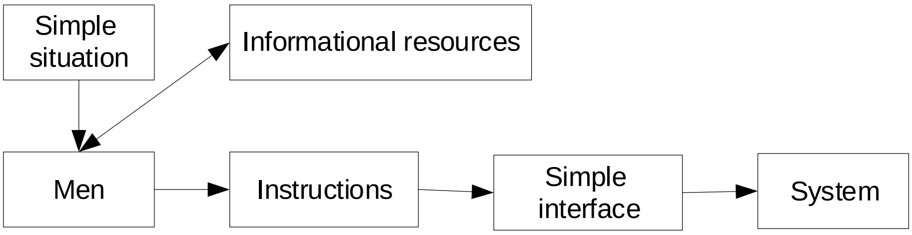

Fig. 1. MMS structure

MMS can be described as regulated systems. They are used in simple situations. For the functioning of MMS, it is enough to use information and technical resources. The operation of MMS is carried out on the basis of instructions. MMS systems use a simple interface based on instructions and prescriptive models.

For comparison, Figure 2 shows a block diagram of ES.

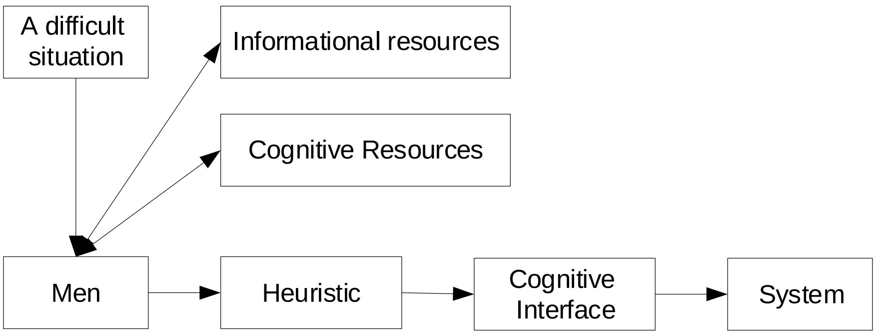

Fig. 2. Structure of ES

ES can be described as cognitive and heuristic systems. ES is used in difficult situations that are not described by the instructions. For ES to function, it is necessary to use information and cognitive resources. The work of ES is carried out on the basis of heuristics or meta-heuristics. ES systems apply a cognitive interface based on a heuristic and subsidiary approach. The organization of the cognitive interface requires the use of formal-logical (Wybraniec-Skardowska, Waldmajer, 2008) and cognitive-logical (Savnykh, Tsvetkov, 2021) approaches.

There is a specialization of ergatic systems. The following types of these systems are distinguished: ergatic control systems, ergatic navigation systems, immersive ergatic systems, ergatic systems in education, ergatic training systems (Obukhovet al., 2018), ergatic expert systems (Veshneva et al., 2015) and others. The variety of functions of ergatic systems gives grounds to distinguish a group of cosmic ergatic systems. Space ergatic systems are ESdesigned to control spacecraft and orbital stations (Savinych, 2018). Space ergatic systems include control, navigation and prevention systems (Mukhin et al., 2018), in which humans play an important role.

The ergatic space system has the property of emergence. ES emergence has different components: intellectual, cognitive, resource, and others. This is the fundamental difference between ES and other systems.

From a system point of view, ES can be described as a tuple

$$ES = F2\langle(CR, VStr, RS, CI, R)\ (\vee NF)\neq\varnothing\rangle \quad (1)$$

In expression (1), CR is the connections and relations in the system, VStr is the variable structure of the system, NF -not factors denotes permissible, but not mandatory "non-factors" or fuzzy factors. These include: information uncertainty, instability of the situation, ambiguity of interpretation of information, fuzzy information, complexity of the situation, significant errors. The logical relation "OR" in (2) means that ES allows for "non-factors". The difference is also in connections and relationships. For MMS, the number of relationships exceeds the number of relationships and relationships play a major role. For ES (1), the number of relationships exceeds the number of relationships, and relationships play a major role. Relationships set rigidity and determinism, relationships set flexibility and adaptability.

3. Conclusion

The ergatic system is a system of human interaction with external reality using the cognitive factor. The ergatic system is not identical to the human-machine system. The ergatic system is adapted to the occurrence of emergency situations. For her, such situations are expected and surmountable. The boundary between MMS and ES is not always clearly marked. It is possible to correlate systems with MMS and ES on the basis of the real situation and the tasks that the system faces. There is a qualitative and systemic difference between MMS and ES. The need to use ES due to the fact that many management and decision-making systems in difficult situations become ineffective. In this case, the solution of the problems of controlling moving objects is possible only with the help of ES. New ergatic systems use artificial intelligence technologies. They demand from operators qualities at the level of the limit of human capabilities. This poses the task of developing special interfaces that reduce the burden on the operator. Moreover, ES requires the development of special models that take into account their specifics. In general, ES is complemented by intelligent, automated, and cyber-physical systems. Ergatic space systems can be thought of as a type of heuristic intelligent systems. The motivation for the use of ergatic systems is to remove information uncertainty and cognitive complexity through cognitive analysis and heuristic analysis. S Many multi-agent systems are ergatic, although they function without human intervention.

References

Bondur, 2015 – *Bondur, V.G.* (2015). Informatsionnye polya v kosmicheskikh issledovaniyakh [Information fields in space research]. *Obrazovatel'nye resursy i tekhnologii*. 2(10): 107-113. [in Russian]

Gospodinov, 2018 – *Gospodinov, S.G.* (2018). The Development of Geodesic Astronomy. *Russian Journal of Astrophysical Research. Series A*. 4(1): 9-33.

Gospodinov, 2022 – *Gospodinov, S.G.* (2022). Evolution of geodetic astronomy. *Russian Journal of Astrophysical Research. Series A*. 8(1): 3-11.

Kudzh, 2022 – *Kudzh, S.A.* (2022). Development of space monitoring. *Russian Journal of Astrophysical Research. Series A*. 8(1): 12-22.

Mukhin i dr., 2018 – *Mukhin, I.E., Mukhin, A.I., Mikhailov, S.N., Koptev, D.S.* (2018). Metodologicheskie osnovy sinteza sistem diagnostiki tekhnicheskogo sostoyaniya kosmicheskikh i letatel'nykh apparatov [Methodological basis for the synthesis of systems for diagnosing the technical condition of space and aircraft]. Kursk, YuZGU, 211 p. [in Russian]

Nosov, 2020 – *Nosov, P.S., Zinchenko, S.M., Nahrybelnyi, Y.A., Palamarchuk, I.V., Popovych, I., Nosova, H.V.* (2020). Development of means for experimental identification of navigator attention in ergatic systems of maritime transport. DOI: 10.31489/2020Ph1/58-69

Obukhovet al., 2018 – *Obukhov, A.D., Dedov, D.L., Arkhipov, A.E.* (2018, March). Development of structural model of adaptive training complex in ergatic systems for professional use. In *IOP Conference Series: Materials Science and Engineering*. 327(2): 022075. IOP Publishing.

Oznamets, 2023 – *Oznamets, V.V.* (2023). The Evolution of Space Geodesy. *Russian Journal of Astrophysical Research. Series A*. 9(1): 14-19.

Pila, Kozuba, 2019 – *Pila, J., Kozuba, J.* (2019). Safety of complex aircraft ergatic systems. *Transport Problems*. 14.

Prokopenko et al, 2021 – *Prokopenko, E. et al.* (2021). Intelligent control based on ergatic systems in conditions of incomplete and fuzzy information. *Journal of Physics: Conference Series*. – IOP Publishing. 2131(2): 022101.

Savinych, 2016 – *Savinych, V.P.* (2016). On the Relation of the Concepts of Space Knowledge, Knowledge, Knowledge of the Spatial. *Russian Journal of Astrophysical Research*. Series A. 1(2): 23-32.

Savinych, 2017 – *Savinych, V.P.* (2017). Evolution of Space Monitoring. *Russian Journal of Astrophysical Research. Series A*. 3(1): 33-40.

Savinych, 2018 – *Savinych, V.P.* (2018). Evolution of the Salyut Space Research Program. *Russian Journal of Astrophysical Research. Series A*. 4(1): 19-33.

Savnykh, Tsvetkov, 2021 – *Savnykh, V.P., Tsvetkov, V.Ya*. (2021). Cognitive Logic's Principles. In *Artificial Intelligence in Intelligent Systems: Proceedings of 10th Computer Science On-line Conference 2021*. 2: 288-296. Springer International Publishing.

Veshneva et al., 2015 – *Veshneva, I., Singatulin, R., Bolshakov, A., Chistyakova, T., Melnikov, L.* (2015). Model of formation of the feedback channel within ergatic systems for monitoring of quality of processes of formation of personnel competences. *International Journal for Quality Research*. 9(3): 459.

Wybraniec-Skardowska, Waldmajer, 2008 - *Wybraniec-Skardowska, U., Waldmajer, J.* (2008). On Language Communication. A Formal-Logical Approach. *Zeszyty Naukowe Wydziału Zamiejscowego w Chorzowie Wyższej Szkoły Bankowej w Poznaniu*. (10): 181-201.

Zombeck, 2006 – *Zombeck, M.V.* (2006). Handbook of space astronomy and astrophysics. Cambridge University Press.