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Ergatic Systems in Space Research

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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.

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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.

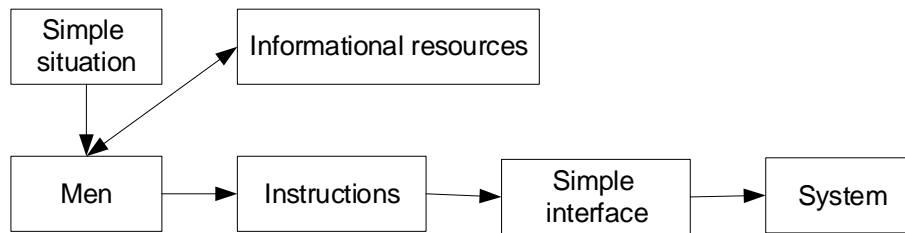


Fig. 1. MMS structure

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.

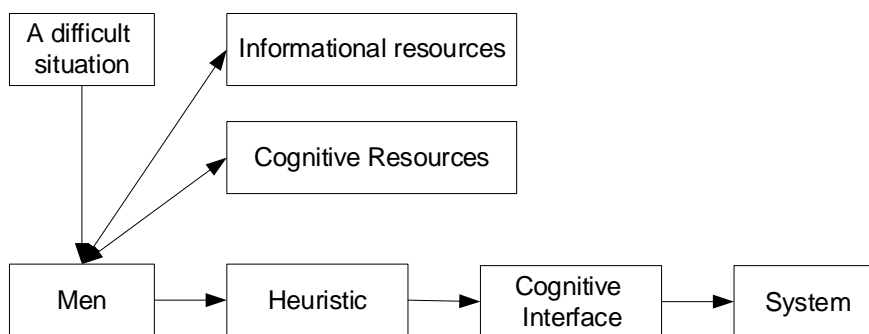


Fig. 2. Structure of ES

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 ES designed 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

$$ES = F_2 \langle (CR, VStr, RS, CI, R) (\vee NF) \neq \emptyset \rangle (1)$$

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.

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