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Space Transport Cyber Space

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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

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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 ($D\neg$) 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) →ΔRP (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 →ΔDP (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 →ΔS (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) ∩Lc→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) →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)→ 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.

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